Magued Iskander
Editor

Innovative Techniques in Instruction Technology, E-learning, E-assessment and Education

Springer

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E-assessment, and Education

mmeybodi@aut.ac.ir

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Edited by

Magued Iskander, PhD., PE
Polytechnic Institute of New York University
New York, NY, USA

Springer

mmeybodi@aut.ac.ir

Editor
Magued Iskander
Polytechnic Insitute
of New York University
Department of Civil Engineering
333 Jay Street
Brooklyn NY 11201
USA

ISBN: 978-1-4020-8738-7 e-ISBN: 978-1-4020-8739-4

Library of Congress Control Number: 2008931889

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mmeybodi@aut.ac.ir

To Sherry, Lauren, & Kito

mmeybodi@aut.ac.ir

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Preface

This book includes the proceedings of the 2007 International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE 07). EIAE 07 is part of the International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering (CISSE 07). The proceedings are a set of rigorously reviewed world-class manuscripts presenting the state of international practice in E-Learning, Instruction Technology, Assessment, and Engineering Education.

EIAE 07 was a high-caliber research conference that was conducted online. CISSE 07 received 750 paper submissions and the final program included 406 accepted papers from more than 80 countries, representing the six continents. Each EIAE07 received at least two reviews (average 3.32 reviews per paper), and authors were required to address review comments prior to presentation and publication.

Conducting EIAE 07 online presented a number of unique advantages, as follows:

- All communications between the authors, reviewers, and conference organizing committee were done on line, which permitted a short six week period from the paper submission deadline to the beginning of the conference.
- PowerPoint presentations, final paper manuscripts were available to registrants for three weeks prior to the start of the conference.
- The conference platform allowed live presentations by several presenters from different locations, with the audio and PowerPoint transmitted to attendees throughout the internet, even on dial up connections. Attendees were able to ask both audio and written questions in a chat room format, and presenters could mark up their slides as they deem fit.
- The live audio presentations were also recorded and distributed to participants along with the power points presentations and paper manuscripts within the conference DVD.

The conference organizers and I are confident that you will find the papers included in this volume interesting and useful. We believe that technology will continue to infuse education thus enriching the educational experience of both students and teachers.

Magued Iskander. PhD, PE
New York, NY
June 2008

mmeybodi@aut.ac.ir

Acknowledgements

The 2007 International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE) and the resulting proceedings could not have been organized without the assistance of a large number of individuals. EIAE is part of the International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering (CISSE). CISSE was founded by Professors Tarek Sobh and Khaled Elleithy in 2005, and they set up mechanisms that put it into action. Andrew Rosca wrote the software that allowed conference management, and interaction between the authors and reviewers online. Mr. Tudor Rosca managed the online conference presentation system and was instrumental in ensuring that the event met the highest professional standards. I also want to acknowledge the roles played by Sarosh Patel and Ms. Susan Kristie, our technical and administrative support team.

The technical co-sponsorship provided by the Institute of Electrical and Electronics Engineers (IEEE) and the University of Bridgeport is gratefully appreciated. I would like to express my thanks to Prof. Toshio Fukuda, Chair of the International Advisory Committee and the members of the EIAE Technical Program Committee, including: James Ritchie, Eman Abdelfattah, Selim Akl, Paul Botosani, Navarun Gupta, Alan Hadad, Abdollah Homaifar, Atef Al-Najjar, Sarosh Patel, Mohmoud Sawan, Abilash Tibrewal, Noel Kriftcher, Vikram Kapila, Ahmed Zobaa, and Bill Taylor, Sarosh H.Patel,. Richard Millham

The excellent contributions of the authors made this world-class document possible. Each paper received two to four reviews. The reviewers worked tirelessly under a tight schedule and their important work is gratefully appreciated. In particular, I want to acknowledge the contributions of the following individuals: C. Harish, Eman Abdelfattah, Bill Taylor, Abilash Tibrewal, Ahmed Zobaa , Alan J.Hadad, Noel Kriftcher, Vikram Kapila, Nadir Abd Elaziz, , Ola Daniel Calin, Mirela Djordjevic, G. Kuleshov, Nerik Yakubov, Edwin Yu, Ola Daniel Calin, Mirela Djordjevic, Krystyna Noga, Javier López-Cuadrado, James Feher, Paras Kaul, Jubin Chheda, Hossain Md.Akbar, Robert Craig, Robert Millham, Sylvia Encheva, Chi Thai, Vanessa Ramoran, and Cao Yali

Finally, I wish to gratefully acknowledge the support I received from Polytechnic Institute of New York University (formerly Polytechnic University) and the National Science Foundation's GK-12 program under grant DGE-0337668 that permitted me to extend my pedagogical interests beyond my own classroom into the k-12 community and share these results through international forums such as EIAE.

Magued Iskander. Ph.D.
New York, NY
June 2008

mmeybodi@aut.ac.ir

Development of Online Internet Laboratory (Online I-Lab)

Adnan Salihbegovic, Samir Ribic
Faculty of Electrical Engineering, Sarajevo, Bosnia & Herzegovina
adnan.salihbegovic@etf.unsa.ba; samir.ribic@etf.unsa.ba

Abstract— **In an internet assisted laboratory (online I-lab) the lab devices and pilot plants are tested, controlled and programmed through a client program or simple web browser at a remote computer. A user-controlled webcam allows monitoring the devices or pilot plant behavior. As an online lab can be used from many locations and at any time, it can be utilized much better than a conventional lab. By working with an online Internet accessible Lab, students and researchers shall not only carry out experiments but also learn how to work, program and design remotely monitored and controlled devices and processes. Online labs will support distributed group work over the Internet. Software to control and program the lab devices and pilot plants runs on central server. Furthermore, user lab access rights will be administered there or on delegated machines called service brokers. Work assignment text and hypermedia course material for the experiment are available from the same site over the Internet. The paper presents one online Internet accessible laboratory built at the Faculty of Electrical Engineering in Sarajevo within the laboratory for HMI/SCADA systems. Pilot plant constitutes of three tanks level control system controlled by Siemens Simatic S7-300 PLC controller. Web enabled HMI software with OPC communication to PLC controller is used to provide full monitoring and control to remote user over pilot plant operation.**

Keywords: remote control laboratories, distance learning, e- learning, internet technologies, web services, thin clients

I. INTRODUCTION

Advancing technology has opened many doors in education. The next step in this direction is interactivity at teaching. Student is able to, not only to see what is involved, but he or she is able to learn from hands on experience [1], [6]. Using computers can be a very effective way of accomplishing this. Students are more motivated and can learn more effectively if they have the opportunity to conduct experiments. Experiments allow a student to compare reality with simulations, collaborate with each other, and give them opportunity to follow their curiosity. Experiments allow a student to compare reality with simulations, collaborate with each other, and give them opportunity to follow their curiosity. Unfortunately, many engineering courses do not include lab component because of significant expense and space considerations. In response to this, I-Lab created remote web-accessible laboratories are providing a new framework of science and engineering courses. Remote laboratories allow for much more efficient use of laboratory equipment and give students the opportunity to conduct experiments from the comfort of his home, with an Internet accessible browser.

These online Internet accessible labs are important in several learning situations. The first of these is the distance learning scenario. In this situation, learners execute a laboratory oriented course or exercise from their homes or places of employment. Individual learners are remote from each other so that *collaboration is distributed.* There are currently an increasingly large number of efforts to provide the online analog of the university classroom. However, there are comparatively few efforts to provide the online analog of the university laboratory, as lectures are much simpler to implement in the Internet environment. However, laboratory learning is a key part of a well designed curriculum. As the number of distance learners and distance learning programs increase, the demand for online laboratory access will also increase [7]. This could for example, also make them available to other national community colleges or partnering Universities and colleges all around the world. So, laboratory-based learning experiences that traditionally have been possible only at universities with abundant funds for research are now accessible to many. Third scenario of application is integration of reality into live lectures and seminars (conditionally named **reality lectures**). In this situation, teachers present to classroom audience a live (but remote) experiment or demonstration controlled by the instructor. In this scenario, the lab is brought online to the classroom.

Economic, space, and cost issues are extremely important and must be considered in setting-up any distance as well as conventional learning environment. Online Laboratories hold promise of being up to three orders of magnitude cheaper to setup than conventional laboratories, requiring less space to run the experiments and being accessible to much larger audience and utilized round the clock.

II. CONCEPTS BEHIND BUILDING ONLINE LABS

Typical online Internet accessible laboratory consists of:

- lab device, instrument or pilot plant equipment for telepresence showing the lab to remote users
- teleconferencing equipment or at least built-in chatting capabilities for collaboration among students and instructor
- control software allowing users to perform experiments, program lab devices and/or run pilot plant.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 1–6.
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- lab scheduling component assigning users time to use the lab
- work assignments for students (each with an example solution for the Instructor)
- tutorial background information on the experiments ,including instructions on how to run pilot plant

Online labs will support distributed group work over the internet. Software to control and program the lab devices runs on a central server or other machines connected to it. Furthermore, student lab access times and access rights will be administered there. Work assignment text and hypermedia course material for the experiment are available over the internet from the same site.

Fundamental concept behind the idea of I-Labs is that we want to make labs accessible to *students and researchers,* as implementation of omnipresent paradigm. Our principal aim in the I-Lab project, however, has been to integrate Internet accessible labs as smoothly as possible into students' educational experience with everything that implies about context and the scalability of such endeavour.

This basic priority leads fairly directly to three goals that affect design:

1. While students are the intended beneficiaries, the people who have to implement it are the faculty and lab staff who must set up and interface the labs to the Internet. So, the most important goal in building them is to provide a software infrastructure that will make it easier and cheaper to make a lab Internet accessible. To the greatest degree possible, one has to do so, without making any assumptions about the nature of the lab itself, the pedagogy used by the faculty, or the academic policies of the educational institution using the lab.

2. One should plan for an environment that can host or offer multiple online labs. The software should not increase the administrative load of either the course or lab staff. Simply put, Internet access opens lab equipment to a wide audience. It must make sure that the software *scales* to it.
   There are also clear advantages to predictable interfaces and administrative procedures. If a student uses more than one Internet accessible lab, he/she should find using the second more natural after using the first. Domain specific aspects of lab equipment and procedures may differ, but the methods a student uses to reserve or connect to a lab, to store or review results, to generate hard copy, etc, should remain as uniform as possible and looks familiar to user. The concept of Internet accessible labs encourages cross-institutional cooperation. One can easily imagine students at one university using a laboratory made accessible by a second university. Schools or universities should be encouraged to share the cost of an expensive laboratory or pilot plant, and physically establish it at a convenient location. In future, as ideas and implementations of online labs proliferate, designers may introduce a search and discovery process by which a student or researcher can locate an online lab that offers a particular experiment, pilot plant or technology.
   These future potential uses require that the I-Lab software architecture separates lab users from lab providers. It also suggests that the architecture should support priorities of use, and eventually distributed resource accounting and allocation time and cost sharing.

The notion of learning behind the concept of online Internet accessible laboratories approach is based on the model of the reflexive subject [5]. In line with this constructivist paradigm, students involved in teaching and learning environment are confronted with a demanding experiment or problematic situation (for instance pilot plant with a technical fault). The distance-learning experiment or reality lecture, creates for the learner a greater proximity to reality due to its concreteness as a physical object, which is inherent in the system, in contrast to pure software simulation. This concreteness also serves to greatly increase the learners' motivation, since they see directly the physical effects of their actions and they are given responsibility for a safety of materially represented process.

III. CLASSIFICATIONS OF THE I-LAB TYPES

Laboratory exercises are part of many university courses curricula. Using computers networked in local University Intranets and world wide Internet, we have come to new types of laboratories which offer greater flexibility allowing access by more students within a given time and making them omnipresent, while reducing the total acquisition, operating and maintenance costs by sharing investment and operational costs among much larger number of institutions involved in their utilization.

In the variety of possible configurations, one can try to classify them in the following distinct categories:

Local Labs

Traditional way of doing experimental or constructive exercises is to go to a university's laboratory. Within that local lab students work in teams with tutorial help from Instructors. Every engineering education should combine theory and practice. The feeling and inner insight that students obtain by sitting in the laboratory will not be provided by simulations. Local labs are still the best way to get a first hands-on experience in operating laboratory devices, and carrying experiments.

Virtual Labs

Virtual labs are software simulations of:

- physical devices (e.g. measurement instruments),
- plant and process dynamics with control system structures
- other real life systems (e.g. economic or biological systems).

Computer animation and visualization can help to illustrate complex relationships during classroom teaching as well as in individual learning at home.

However, is very expensive and time consuming to implement simulations which come close to reality, because one needs to take into account far too many parameters and dependencies.

mmeybodi@aut.ac.ir

Furthermore, if the behavior of the real system cannot be formalized by mathematical functions or precise rules, simulation is used to show general principles only.
Simulations are nevertheless artificial and do not represent reality. If the lab experiment needs to show very specific effects or teach specific knowledge and skill as on pilot plant or trainer, one has to use local or online labs.

Online I-Labs

In widely accepted definition, online Internet laboratories offer remote access to laboratory equipment, workbenches and all types of experiments via the Internet [1].
Online labs try to combine the advantages of local physical labs with the flexibility of simulations [2]. Additionally, online experimentation will develop engineering skills like remote operation, diagnosis and maintenance, and collaborative teleworking, which are becoming increasingly important for the students to acquire them for their future work environment with more and more jobs performed remotely.
In an internet accessible laboratory (online I-lab), the lab devices are controlled and programmed through a web browser at a remote computer. A user-controlled webcam allows monitoring the devices' behavior. As an online lab can be used from many locations, it can be utilized by much larger audience and in longer time span than a conventional lab.

IV. STRUCTURE OF ONLINE INTERNET ACCESSIBLE LABS

Our introductory work based on the initial online lab built at ETF-Sarajevo, suggests that a single shared architecture would be too limiting. We have reached conclusion that it will be necessary to distinguish three types of laboratory experiments. These three categories of experiments possess different types of lab sessions and, hence, require different software architectures.

1) Batched Experiment

In a *batched experiment*, the student specifies all parameters that govern the execution of the experiment before the experiment starts. The lab session consists of submitting an experiment protocol, executing the experiment, and then retrieving and analyzing the results. Typically, batched experiments run quickly so that scheduling is rarely necessary. This type of experiment is common to the ones previously described as virtual lab, the difference being in physical implementation of experiment.
Requirements on visual feedback from experiment are modest and could be easily satisfied even in the online connection to the site with modest bandwidth [10].

2) Sensor Experiment

In a sensor experiment, the student usually can not specify any parameters although he/she may be able to select the particular sensor data that student wishes to receive. Running the experiment consists of subscribing to real time sensor data, usually presented in a graphical user interface such as a virtual strip chart. The system may provide options to filter the data or to transform it as well as to access archival data. Long running sensor subscriptions may benefit from implementing trigger or alarm mechanisms [5].
Sensor experiments frequently have very asymmetric data flows. It takes several bytes of data sent with a message to subscribe to a sensor, but the resulting data stream from the sensor to the student's client may require a great deal of bandwidth. Some sensors may only provide best efforts to deliver continuous data with no guarantee that all samples will arrive. Other systems may provide archival quality data but perhaps with a variable lag time.
Here, in the conditions of limited bandwidth connection to the source of sensor data, one can benefit from importing sensor achieved data connecting as OPC HDA client, and using delivered set of data in locally run offline experiment.

3) Interactive Experiment

In an interactive experiment or run-up of pilot plant, the student typically sets a series of parameters, initiates the experiment, and then monitors the experiment's course or pilot plant operation, changing control and tuning parameters as necessary. Conceptually, an interactive experiment can be thought of as a sequence of alternating control and monitoring intervals. In general, the control intervals have many of the characteristics of a batched experiment, and the monitoring intervals resemble sensor experiments. The record of an experiment session typically includes time-stamped control and sensor data as well as other forms of documentation that may include images or video. Our experimental setup of Internet accessible pilot plant with level controllers based on Simatic S7-300 PLC provides a good example of this type of experiment.

V. SOFTWARE ARCHITECTURE CONSIDERATION

Theoretically, the software framework and the network technologies to use to build online Internet accessible labs are implementation issues.
With the rise of middleware and distributed application frameworks, one's choice of a distributed computing strategy symbiotically affect the whole design of such a project.
There are design requirements in the I-Lab Project that immediately favor the use of web services. Students on one university must be able to use a lab housed on a second university or college. This requires an architecture that supports both lab-side services (e.g., the online lab itself, a reservation service for the lab) and client or student-side services (authentication and authorization, class management, student data storage for experiment specifications and results as well as user preferences). The lab side services may need to run on a different hardware and software platform than the client-side student software. The lab-side location may enforce different networking policies (e.g., firewalls, directory and email services) than the client-side location. The transparency of web services makes this technology an obvious choice to integrate our distributed application framework.
Very often existing labs have a large pre-existing code-base to manage the lab equipment or to display results and control the lab equipment from one or more client machines. The loose coupling of web services makes it easier to reuse this legacy codebase as the basis of the Internet accessible implementation. It will also make it much easier to incorporate vendor supplied modules in the overall architecture.

mmeybodi@aut.ac.ir

Some Universities and colleges may be much more interested in becoming clients of such labs than in offering online labs themselves. They will need a means of discovering what online labs are available in their area of interest and of verifying that those labs are compatible both with their campus networking and software install base as well as the pedagogic goals of their courses. [9].

Web Services WSDL and UDDI provide a framework in which to conduct this discovery process. To carry this one step further, one can imagine WSDL-based negotiation that will match an Internet accessible lab with high end visualization and data analysis tools that are licensed by the client-side campus.

The XML based Web Services are emerging as tools for creating next generation distributed systems that are expected to facilitate program-to-program interaction without the user-to-program interaction. Besides recognizing the heterogeneity as a fundamental ingredient, these web services, independent of platform and development environment, can be packaged and published on the internet as they can communicate with other systems using the common protocols like HTTP and SOAP.

The synoptic view of the Web Services is that the WSDL(Web Services Description Language) is used to create a Web Service that defines its interfaces and invocation methods, followed by publishing to one or more intranet or Internet repositories for potential users to locate, where UDDI(Universal Description, Discovery and Integration) is used to locate the web service and eventually the SOAP(Simple object Access Protocol) messages are used to invoke and consume the web service.

The stability of this web services vehicle is due to the four-wheel drive of WSDL, UDDI, XML and SOAP, with an alloy body framework of either .Net or J2EE. Web Services reduce the complexity by encapsulation and minimize the requirements for shared understanding by clear definition.

Also web services enable just-in-time integration and interoperability of legacy applications. Based on open and pervasive standards, Web services seem poised for success, as these are only built on top of existing, ubiquitous infrastructure like HTTP and XML. For all of these reasons above, we are planning to base our shared software infrastructure for Internet accessible labs on web services. But it is also important to recognize that web services will not solve all the networking requirements of Internet accessible labs. Consider an online sensor lab that wants to multicast high bandwidth sensor data to subscribed clients. While web services may aid the subscription process, they don't provide any support for streaming the multicast data to the students' clients, and ubiquitous requirements of bandwidth and quality of Internet connection at client side remain unchanged.

Furthermore, Server -client architecture seems to be still unrivalled candidate for the basic structure of the system software architecture, broadened with the introduction of multiagents and service brokers on client side.

.The Lab Servers shall not know on which student's behalf it is executing an experiment. It only knows the requesting Service Broker and the effective group associated with the request from that service broker.

In this architecture for the batched experiment the student's workstation never contacts the Lab Server directly. One can maintain this strict discipline because the batched experiment requires so little communication between the client and the Lab Server. Conceptually, the execution of an experiment requires a single round trip, although the actual Web Service protocol shall be more complicated. This simplicity obviously does not extend to the cases of a streaming sensor experiment or an interactive experiment in which there are strong arguments for having the Service Broker authenticate the student's client before allowing it to connect to the Lab Server directly.

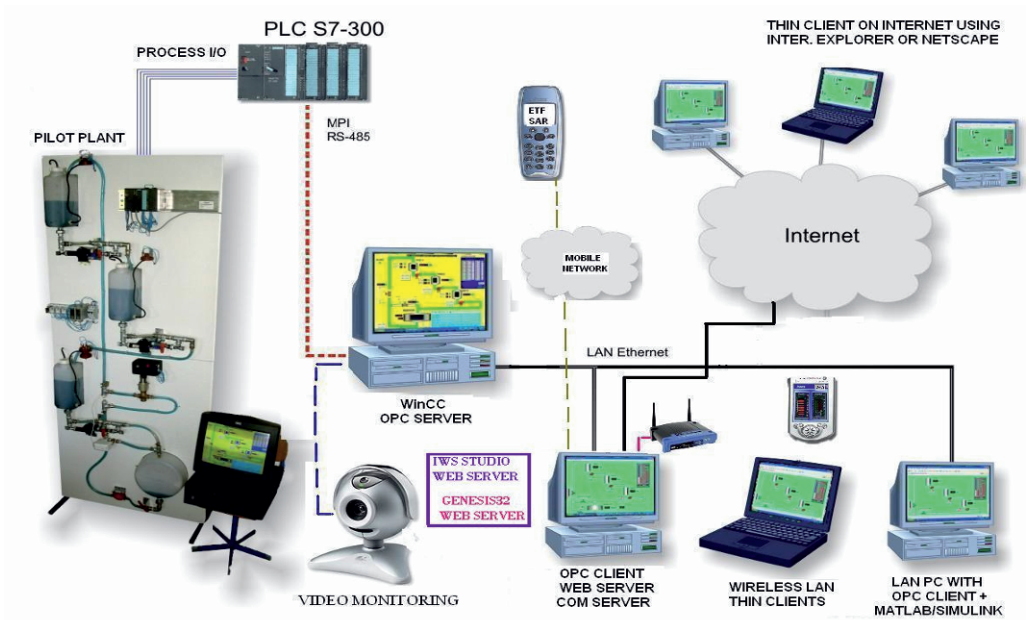


Fig. 1. Legend: On Line Lab Technology

mmeybodi@aut.ac.ir

VI. DESCRIPTION OF IMPLEMENTATION OF THE I-LAB

In our implementation of the online Internet lab, as transient solution, while building full fledged solution on described software architecture and generic code that would be applicable to wide variety of lab configurations, we have made use of readily available software applications and open communication protocols to bind them together and made Internet and online accessible.

In our online lab, whose topology is depicted on the Figure 1 above, it is possible to monitor and eventually control (by the authorized users), pilot plant from anywhere in the world using standard Web Browser.

Laboratory experiments and running of the pilot plant can be observed online in one of the screens of Web browser, through one or two pan, tilt and zoom web cameras controlled remotely by users, that are sending their streaming signals via ftp server running web server of HMI application created to connect remote clients to the pilot plant controller, as shown on the following Fig. 2.

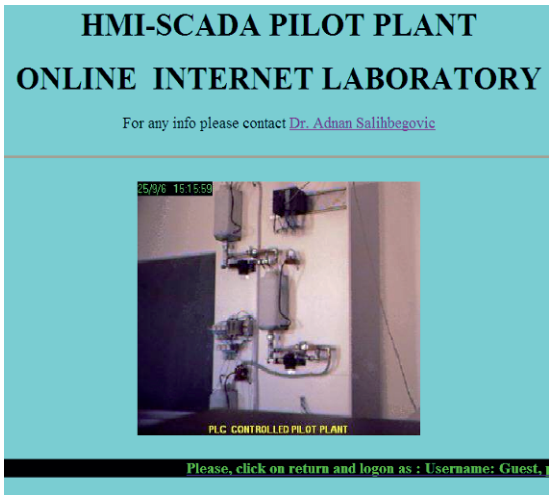


Fig. 2 Video stream of the Lab pilot plant

Pilot plant itself consists of three tanks interconnected in-between through direct pipe connections and in parallel with pumps, in order to crate different plant configurations with various dynamics. Lowest lying is reservoir from which the water is pumped to top most tank using bottom installed pump. Two servo control valves are controlling the flows in bypass line and return line taking water from the third lowest tank back to reservoir.

Level transmitters measuring tank levels, as well as pumps and control valves signals are connected via analog and digital input and output modules to Siemens PLC controller of the type S7-300, which is programmed in Step7 programming language to control the tank levels with variety of PID and fuzzy controller algorithms, and performing all protection functions which are preventing the equipment from being damaged or water spillage from overflowing tanks, due to inadvertent control from remote users Siemens S7-300 PLC controller is connected via MPI interface (Siemens proprietary serial multidrop bus connection) to the PC computer within the Lab on which is installed and running WinCC software package of the same manufacturer used as HMI (human machine interface) for the local lab users, that are carrying lab experiments within the Laboratory.

To connect remote users via Intranet within the Faculty, or distance users connecting via Internet, we are running WinCC OPC Server DA, which is industry standard communication protocol for real-time process data exchange.

One of the OPC DA client connected to the WinCC OPC Server is HMI software application built on top of another HMI software application (IWS from Indusoft) , which is running in another Laboratory PC with dual connection to local Intranet network as well as external Internet. That software application is running as Web server broadcasting html versions of its HMI screens using ActiveX technology to all clients connecting to it using standard Web browsers (either Internet Explorer or Netscape). Remote users are connecting either within Faculty Intranet local network (wired or wireless) in application like described live lectures (reality lectures) or demonstration and tutorial held outside the Lab itself, when the number of participants outnumber limited Lab capacity to host them locally.

Majority of the Lab users connect to Lab and work remotely via Internet from the commodity of their own home and at the time they choose, complying with time schedule and booking in case that are going to carry active experiments on the Lab and pilot plant itself. To enable group online work and exchange of information between the online participants, the Web application is integrating screen with chatting like capabilities as shown on the following figure 3.

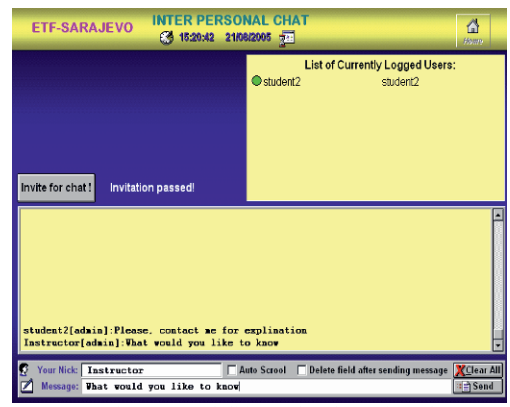


Figure 3 Chatting capabilities within the Web application

Beside of described chatting, remote user can easily send email to any address from within application, without need to leave it and open another window with mail client application to do it.

To further enhance online connectivity to the Lab, we have equipped the Lab PC server with connection to mobile phone unit (via Bluetooth connection to PC) and software driver that integrates this communication channel to the HMI application,

mmeybodi@aut.ac.ir

so the software is capable to send SMS messages based on process events (like alarms) to specified mobile recipients or to accept remote commands sent via mobile phone as SMS coded messages.

Furthermore, making use of standard OPC communication protocols used in this Project, we can readily exchange live process data from pilot plant with many software applications in real time running on any computer within the Faculty on local Intranet. The good example for this depicted on the above Figure No.1, is connection via OPC tags to Matlab/Simulink (from Version 7.0) so that we can readily implement the ‘‘hardware in the loop” configuration, in which we use Simulink to configure control structure algorithms and closed the control loop via pilot plant real physical object in the loop.

Demonstration of the integration of the Web services to the application has been verified on the Web HMI server where Excel spread sheet connected via DDE protocol with application has been connected to live data from several Internet sites, integrating process and Web based live data into a meaningful service useful in every real life software application.

VII. DESCRIPTION OF THE POSSIBLE REMOTE I-LAB EXPERIMENTS

The functionality of the implemented online Internet laboratory encompassing pilot plant with S7-300 PLC controller is matching and in some aspects extending beyond the functionalities available for local users.

Among others, the remote Intranet/Internet accessible user to the pilot plant is capable of doing the following set of exercise and experiments:

- carrying out monitoring and control of pilot plant control loops
- tuning the controller parameters and observing and recording effects of parameter changes for reporting and analysis.
- using pilot plant live data as signal sources (second type of online experiments named sensor experiment), to archive them and further process offline in various signal processing, identification and simulation applications.
- using pilot plant live data as OPC signals in OPC client enabled applications like Matlab/Simulink to implement experiments like “hardware in the loop”, in which Simulink is used as analysis and synthesis tool of various control structures and algorithms acting upon live physical plant, with all its intricacies and nonlinearities.
- using pilot plant live data as OPC signals in various online identification packages like Matlab system identification toolkit (SIT),for online identification and model building tool.

Since OPC DA communication is based on COM and DCOM mechanisms which are operating satisfactory only in Intranet networks but not over Internet, these last two applications can be carried out only on PC computers connected to Lab Server within the Faculty, but we are investigating the possibility to transfer the signals between Lab OPC servers and remote OPC clients using other protocols like TCP/IP or SOAP/XML , especially in applications where the dynamics of live process signals on the Lab server side is tolerating OPC data transfer and refreshing speed at client side not greater then 1 Hz for acceptable real time performance and results.

VIII. CONCLUSIONS

Despite of the limited perception (limited to computer screen), online remote laboratory user is in many aspects in advantage to his local Lab fellow user, not only that he can use it at his own pace and time, but in collaborative team that he/she decides to join. Internet based forms of learning have been broadened to encompass live physical experiments, which is although much more complicated to implement in comparison to lecture modules, bringing these expensive teaching tools to broader audience promoting ideas of interinstitutional joint laboratory assets.

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mmeybodi@aut.ac.ir

E-Assessment Tool: A Course Assessment Tool Integrated into Knowledge Assessment

A. M. Rashad, Aliaa A. A. Youssif, R. A. Abdel-Ghafar, Ahmed E. Labib
Helwan University
Egypt
{armoussa, aliaay, rghafar, ahmedezzat}@helwan.edu.eg

Abstract— **An Electronic Assessment System (EAT) is introduced to improve the teaching process in an E-learning environment. The system provides the instructor with assistance to modify the course contents. Since student is a key element in teaching, EAT takes into account the student answer, answer-time and student feedback as parameters.**

In EAT; instructors can generate a test in Multiple Choice Questions (MCQ) form. Also, it gives the instructor an absolute management on database. EAT provides both the student and the instructor with a Web-based forums to retain their feedback. This work provides a case study on the use of EAT in e-learning. The outcome of the case study is analyzed to evaluate the performance of the system.

I. Introduction

A few years ago, Internet was nothing more than a de-centralized network of computers. Recently, Internet seems to be heading towards the networking of all appliances in our life. Internet encourages us to convert almost our needs to electronic needs (E-need), something like E-Book, E-Culture, E-Music, E-Learning, and so on.

E-Learning is one of the most important applications and it has many criteria. E-learning was changed from an instructor-centred to a student-centred model; these models are realisations of the instructionist model and constructivist model respectively [1]. The instructionist model, knowledge and information are transferred from the instructor to the student, while the constructivist model mainly focuses on the learning process, and the aims of assessment in both models are different.

Assessment in the instructionist model (instructor-centerd model) was used to tell students about the level of their achievement or grading students, but in the constructivist model (student-centerd model), assessment was used to diagnose learning problems to find a way to solve it, and promote further learning [2].

Most organizations offering online learning material, must examine the role of assessment and evaluation in this new learning medium [3]. These assessment-results can enhance the E-learning System. There are two types of assessment: Summative assessment and Formative assessment. Summative assessment is an assessment used for grading and telling students what they have achieved [4]. It can be used to assist the learning process by providing feedback to the student, which can be used to highlight areas for further study and performance improvement [4].

The other type of assessment "formative assessment" is used to promote learning. It is designed to provide the instructor with rich feedback according to the assessment technique. Time and feedback are essential parts of the student-centred assessment.

Both types have been used in this paper to assess the quality of the course and to discover the week points of the course, which may disturb students, so that the instructor can fix them. ETA provides the instructor and the student with valuable feedback.

Feedback can perform several functions depending on the purpose of assessment [5]. ETA combines both the student answer and the student feedback with the student answer-time to give the instructor a complete view about his/her course. ETA can assess the performance of the student to improve his/her self-learning capabilities.

This paper is divided into five sections: section 1 explains the difference between "Assessment for Learning" and "Assessment of Learning". The Integrated Assessment System (IAS) is introduced in section 2. ETA is explained in section 3. The outcomes of applying the system to a group of students are shown in section 4. The conclusion is introduced in scetion5.

II. Assessment For Learning Versus Assessment Of Learning

In 2004, Hall mentioned "A true education requires far more than prepackaged tests and a box of Number 2 pencils".

The range of assessment practices in various organizations reflects educational traditions established in the past. These assessment systems may vary according to educational traditions, but they often share the following characteristics: they fail too many learners by the following:

-- Focusing on assessment of learning instead of assessment for learning.

--Being limited in scope.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 7–12.
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mmeybodi@aut.ac.ir

--Driving the teaching (teaching for assessment)
--Ignoring individual learner differences.

These factors contribute to the failure or the rejection of a range of learners within the current Electronic Education Systems.

Current assessment practices tend to focus on Assessment of learning. These assessments largely fail to address assessment for learning, assessment as a means to measure learner progression and to inform the learners about their progression [6]. In other words, a paradigm shift from assessment of learning towards assessment for learning is required.

This paradigm shift ultimately is aimed at making assessment part of the curriculum (Assessment for Learning), so assessment for learning will be multi-dimensional, formative, teaching for learning, authentic, context embedded, and flexible [6]. See Figure 1.

In the next section, an IAS is introduced. It dos not exclude assessment of learning. It aims to combine both formative and summative assessment as two different ways of 'testing' learners, whilst giving both learners and teachers insights into the learning processes at work.

III. Integrated Assessment System (IAS)

Integrated Assessment System (IAS) would be beneficial to both students and instructors. So, the implementation of Integrated Assessment System (IAS) would allow instructors to:

1) Spend time focusing on developing the teaching of the teaching of the curriculum instead of teaching to the test.
2) Spend less time with the preparation and administration of assessment.
3) Get useful information about individual learners' progress.
4) Furthermore, the implementation of Integrated Assessment Systems (IAS) would allow students to: Test themselves both independently and/or as directed by the instructor.

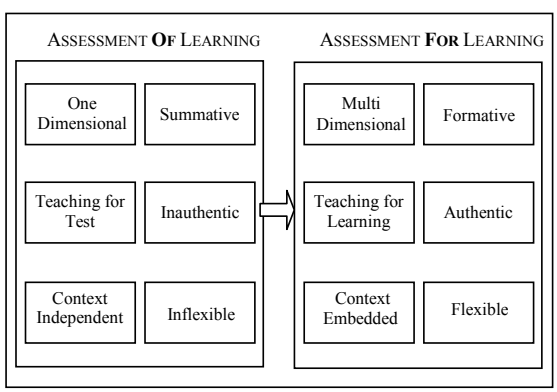


Fig. 1. Shifting from Assessment of Learning to Assessment for Learning

5) Get information about their individual learning progression.
6) Develop his/her problem solving skills. See Figure 2.

The uses of technology in learning environment lead us to develop an Integrated Assessment System (IAS) to meet the new trends of e-learning and e-assessment [7], so we can use a computer to assess the performance of the learning process, we can summarize this definition in just three words Computer Assisted Assessment (CAA).

Finally, E-assessment will play a major role in developing Integrated Assessment System (IAS) using the following points:

1) Integrate both new and old ways of assessment.
2) Provide new perspectives on test validity.
3) Develop new methods.
4) Integrate formative and summative assessment modes [6].

In this paper, it will be identified key factors of assessment technique that should be taken into account when constructing E-Assessment Tool (EAT).

IV. E-Assessment Tool (EAT)

EAT is a web-application for CAA, it is based on the combination of three parameters that are the student answer of each question, the feedback that get from student himself , and the student answer time for each question using a technique (it will be described in details in the next sections).

EAT consist of four mainly sections:

1) Instructor Space.
2) Assessment Preparation.
3) Student Space.
4) Data Analysis.

The architecture EAT is shown in Figure 3. More detailed discussion of the elements of the EAT are given in the next paragraphs.

A. Instructor Space

EAT gives instructors an absolute management on the database. So, they can build their own courses (in pdf or PowerPoint format) and manage the questions database.
The instructor will be logged in the system, he is directed to own a web page that contains a course area, test area, and a report area (so these areas will be described in detail later).

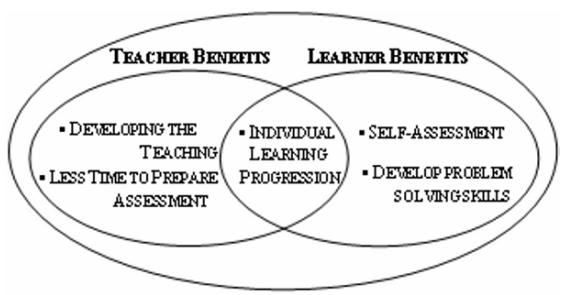


Fig. 2. Benefits of an Integrated Assessment System

mmeybodi@aut.ac.ir

Also, in order to help the instructor to administrate the assessment process the tool gives him the ability to view the student database.

Furthermore, EAT helps the instructor to browse the database in different views according to the course, the exam type and the student.

B. Assessment Preparation

The assessment technique in this system is based on an online test using MCQs.

Initially, the instructor must choose the test type (Assignment – Quiz – Mid-term Exam – final Exam), and he must determine the number of questions and the total mark.

The assessment strategy was dependent on classifying the questions into five groups from 'A' to 'E'. By this classification, the instructor can be divided any part of the course (e.g. chapter or topic) that will be assessed into small parts to help the instructor in finding the parts that need to be modified in the course.

Another question group in this system named 'F' group questions or Feedback questions. It will be prepared by the instructor to ask the student about his/her opinion after each group of questions that he/she answered previously to know his/her opinion on this group or on this part of the course.

Test Setup

This setup is prepared by the instructor, so he/she will write all details about his/her test (test name, test type, number of questions, and the total mark), and he/she starts to write every question as will be describe:

1) Choose the question group (from 'A' to 'E').
2) Determine the question time (QT).
3) Write the question and determine the number of choices from two to eight choices and mark on the correct answer or answers (if the question have more that one correct answer) in the checkbox behind every choice.
4) Determine an interval time (IT) for each question, the instructor needs in this interval to take into consideration the individual difference in thinking between the students.
5) he instructor will put a question of 'F' group questions (Feedback) after each group of questions ('A' to 'E'), the purpose of this question is the instructor can determine the student opinion in this group of questions or the understandable of this part or topic in the course material.

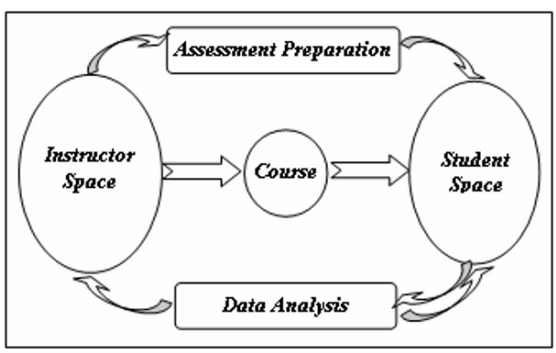


Fig. 3. Architecture of EAT

Any question of 'F' group questions has only two choices about the student satisfaction or dissatisfaction (agreement or disagreement).

Subsequent to completing all test questions, the instructor can put another general 'F' group questions to ask the student generally about his/her opinion on the usability of this system and how the student is adaptive with this system, and the student can answer these questions by agreement or normally or disagreement.

Finally, after the test setup is completed, the instructor can edit his test by adding or deleting any questions in the test.

C. Student Space

In this section students are required to register themselves prior to enter the system by filling in an online registration form, this profiling section obtains personal data (e.g. name, phone number, e-mail address, gender), and any previous experience with online tests.

The next stage, the student is directed to his/her own web page that consists of his/her courses, tests, and reports. In the test area, student can take the tests provided by the instructor.

The student will be provided with a report after submitting the test, this report containing the student answers and the correct answers of the test and a hyperlinks to the course materials that explains the correct answers to help students to improve there performance, also, the report contain the student mark.

D. Data Analysis

Consequently, the students take any test, the system automatically gathering and analysis the data that provided by students in the tests in different strategies. The first strategy is to give each student his/her mark after each test immediately.

The second strategy is the main strategy in this paper; here we will find the points that disturb the students in the course using the combination of three parameters:

1) The student answers time for each question.
2) The feedback that get from student for each 'F' group question after each group of questions ('A' to 'E').
3) The student answer for each question (correct or wrong answer).

Table I describes sixteen relations that was combined the previous parameters.

For example, the first relation described the student satisfaction for specified topic or group of questions if his/her answer was true and his/her answer time was less than half the question time and his/her feedback (opinion in the description of this topic or group) was agreed.

On the other hand, the fourth relation in table I described the student opinion for modifying a specified topic or group of questions if his/her answer was true and his/her answer time was greater than the question time plus the interval time and his/her feedback (opinion in the description of this topic or

mmeybodi@aut.ac.ir

TABLE I
THE BASIC ASSESSMENT RELATIONS IN EAT

ANSWER	STUDENT ANSWER TIME	STUDENT FEEDBACK	DECISION
True	<= 0.5 Q.T.	Agree	Satisfy
True	<= Q.T.	Agree	Satisfy
True	<= Q.T. + I.T.	Agree	Satisfy
True	> Q.T. + I.T.	Agree	Modify
False	<= 0.5 Q.T.	Agree	Satisfy
False	<= Q.T.	Agree	Satisfy
False	<= Q.T. + I.T.	Agree	Satisfy
False	> Q.T. + I.T.	Agree	Modify
True	<= 0.5 Q.T.	Disagree	Modify
True	<= Q.T.	Disagree	Satisfy
True	<= Q.T. + I.T.	Disagree	Satisfy
True	> Q.T. + I.T.	Disagree	Modify
False	<= 0.5 Q.T.	Disagree	Modify
False	<= Q.T.	Disagree	Modify
False	<= Q.T. + I.T.	Disagree	Modify
False	> Q.T. + I.T.	Disagree	Modify

group) was agreed. Here the instructor need to modify his/her topic because the student spend long time for answering, it meaning that this topic need more clarifying.

Finally, the third strategy aims to gathering data that result from the general feedback questions that asked after the test to determine how students adaptive with this system.

E. Reports

1) Student Report: This report consists of the mark of the student in each test and the answers of his/her test and the correct answers of this test and hyperlinks to the topics that explaining the correct answers.

2) Instructor Reports

a) Instructor-Student report: This report inform the instructor about his students profiles that enrolled in his course, the tests that taken by students, number of students that taken every test, the test answers for each student, and the grades of each student.

b) Instructor-Course report: Here the system produces a graphical representation shows the modification percentage of the topic that was assessed by students in each group in the test (see Figure 4). Also the system generates a statistical table that shows important findings (see Table II).

V. A CASE STUDY

The study used for this paper is a Computer Programming Language course (Java) taught in Faculty of Science, Helwan university. This course is available in four different majors at undergraduate level. The course consists of 75% examination (25% for mid-term exam and 50% for final exam) and 25% of an assignment.

In the e-learning lab we chose a random sample consist of twenty one students enrolled in EAT (E-Assessment Tool) system. The design of the experiment included two steps. In the first step every student is being given a guidance that describe all instructions in the system and the system was tested by all the students in 3 days. A questionnaire was constructed in the third day to investigate the students' opinions about the system.

In the second step all students entered the system and used all sources on it.

The students are asked to answer the feedback questions on the functionality and the usability of the system after each assignment or quiz or mid-term or final exam, and the students will receive a report about the test, and an immediately feedback about his/her performance in this test, which is one of the advantages of CAA.

The instructor will receive a rich reports that describes the aims of using this assessment tool as we will describe later.

The results of this paper were built on a sample of twenty one students. The course here contain seven exams and this study concerning statistically on two exams.

The first exam consists of thirty nine questions divided into ten questions in 'A' group, ten questions in 'B' group, fourteen questions in group 'C', and five questions in 'D' group. The students answer a feedback question after each group to express his/her opinion in the previous group or topic.

All the twenty one students complete this exam, and some results are highlighted to the instructor using the assessment technique that was described previously.

The satisfactory percentage of the students in group 'A' questions is 79.52% and the need to modifying percentage in this group (or topic) is 20.47%. In group 'B' questions the satisfactory is 82.38% and the need to modifying percentage is 17.61%. Group 'C' questions, 62.24% of students were satisfied and the need to modifying percentage is 37.75%. Finally in group 'D' questions the satisfactory is 39.04% and the need to modifying percentage is 60.95%. See Figure 4.

Other important results were generated via the system according to the student answer time that takes in each question. There are four questions out of ten questions in group 'A' was answered in an average answer time is less than half the question answer time that is specified for each question. In addition there are six questions out of ten questions in group 'A' was answered in an average answer time is less than the question answer time of each question. Finally, Table II shows this statistics for exam one.

The second exam consists of twenty five questions divided into thirteen questions in group 'A', six questions in group 'B', and six questions in group 'C'. Also, after each group there is a feedback question about the student opinion in the previous group or topic.

The need to modifying percentage for group 'A' is 8.79%, but in group 'B' is 57.14%, and finally in group 'C' is 40.47%. Figure 4 shows all the percentages of modification for each group in both exams, and Table II shows some statistics for exam two.

The students are being asked seven questions after completing each exam (three questions for the system usability and four questions for the functionality) about the system usability and functionality. 73.32% of students'

mmeybodi@aut.ac.ir

opinion after taking the first exam was positive and they found that the system was usable and 76.80% found that the system feedback was very useful to control their self-study and the system functionality was good.

Most students change their opinion to the best after taking the second exam, so 79.14% found that the system was usable and 82.50% found that the system was useful and it work properly to enhance their knowledge and studying.

Finally, after all statistics and the feedback data that is produced by this tool, we have an important question that *"Who has the decision to modify the course material to meet the students' needs?"*, of course the instructor.

EAT give the instructor a very useful information to find the points of weakness in his/her course that make a disturbance to the students. See figure 1, the modification percentage of group 'D' in exam one was 60.95%, so the instructor must review this topic (or chapter) to cover the point of weakness to meet the student's needs and to make this topic more understandable by students.

Another facts comes from Table II, there are no questions (in any group) have an average answer time greater than the question answer time plus the interval time (IT), this tell the instructor that the questions answer time in exam one was appropriate to all students. On the other hand, in exam two there are two questions exceed the question answer time plus the interval time (one in group 'B' and one in group 'C'), so the instructor should review the questions answer time or the topic of this questions to enhance the student understandable and the student answer time.

VI. Conclusion

The paper was focused on applying the concept of Integrated Assessment System (IAS) in Computer Assisted Assessment (CAA) using special technique that depend on the combination of three parameters the student answer, the student feedback and the student answer time.

EAT is a web-application for CAA, it has been designed to provide the instructor and the student with many forms of rich feedback. EAT able to assess the quality of the course and discover points of weakness that may disturb the students. Also the system was able to assess the performance of the students to enhance their self-learning.

EAT has been used at faculty of Science, Helwan university in a Computer programming language course (Java).
The early findings of using this system has been promising.

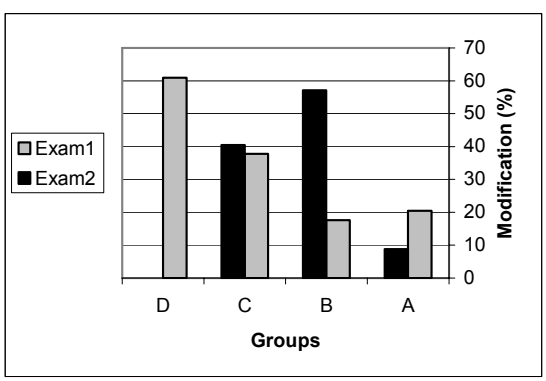


Fig. 4. The Modification Percentage for each group in Exam1 and Exam2.

TABLE II
Classifying The Questions According to The Average Answer Time

Exam	Average answer time	Group A	Group B	Group C	Group D
Exam 1	less than 0.5*QT	4	2	3	–
	less than QT	6	8	9	2
	less than QT + IT	–	–	2	3
	greater than QT + IT	–	–	–	–
Exam 2	less than 0.5*QT	3	–	–	–
	less than QT	10	3	2	–
	less than QT + IT	–	2	2	–
	greater than QT + IT	–	1	1	–

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Developing Educational Applications Using Adaptive E-Learning Model

Amar Balla
National Institute of Computer Science
BP 68 M, Oued-Smar, 16309, Algiers, Algeria
amar_balla@yahoo.fr

Akila Sarirete
Effat College
PO Box 34689, Jeddah 21478, Saudi Arabia
asarirete@effatcollege.edu.sa

Abstract – **In the last few years the problem of developing sequencing course material has become an important research issue. Our work aims at providing an environment of authoring and presenting pedagogical hypermedia contents adapted to the end-user. This environment should increase the productivity of the teacher by supporting the re-use of contents already developed in other contexts. This goal is achieved by means of a model of pedagogical components. In this paper, we propose a three-layer model consisting of a domain model which represents the concepts covered by the courses, a learner model which keeps the profile of learners, and a pedagogical activity model which describes components' content related to the domain model. A hypermedia subsystem is responsible for modeling the navigational aspect of the system. The aim of our work is to provide an environment of authoring and delivering adapted teaching contents to the end-user by combining components. These components, available on the Web, could be accessible and exchanged among teachers in a community. In order to validate and evaluate our model, we developed and implemented a training help application for an educational hypermedia, HyperMadrassa System. This system is aimed at the training of primary school learners' pupils in basic Arabic language concepts.**

Keywords: **- pedagogical components, pedagogical activity, adaptive learning, learning objects.**

I. Introduction

With the widespread adoption of internet and web technologies, new forms of educational applications have been emerging. And old learning paradigms are changing. Not only is learning "anywhere and anytime" required, but also flexible learning environments are needed to allow learners to adapt courses according to their personal preferences and skills.

The dissemination of knowledge via the Internet requires the availability of teaching contents adapted to different publics. The existing commercial proposals facilitate the generation of courses. However, these proposals could not satisfy the keen and pressing market demand. Indeed, with each creation of courses, the contents are completely redefined. However, the fast development of technologies in the Internet and the Web allows more efficient exchange of information. The course authors re-use more and more external documents and want to effectively re-use their own documents (partially or entirely) [1]. Hypergap [2] or Smart-learning [3] projects propose an approach based on the generic course notion to envision pedagogical sequences.

Our proposed training system [4] is based on four models: the domain model which represents the concepts covered by the courses, the learner model which keeps the learners' profile, the pedagogical activity model which describes the components' content related to the domain model, and the hypermedia subsystem which is responsible for modeling the navigational aspect of the system. The delivery process uses the four models to allow the selection of the most adapted components and to group them in a coherent way according to the teaching objectives and learner's profile.

In this article, we emphasise the pedagogical model and the authoring and delivering processes. The aim of our work is then to provide an environment of authoring and delivering adapted teaching contents to the end-user by combining components (also called teaching objects [4][5]). These components, available on the Web, could be accessible, and exchanged between teachers in an educational community. All these components will constitute a common knowledge base, thus encouraging the collection of the teaching resources [6].

II. Related work

A Learning Management System (LMS) is a high-level, strategic solution for planning, delivering, and managing all learning events within an organization, including online, virtual classrooms and instructor-led courses [7]. The focus of a LMS is to manage learners by keeping track of their progress and performance across all types of training activities, but it is not generally used to create course content [7]. In contrast, the focus of a Learning Content Management System (LCMS) is on course content creation [7]. It gives authors, instructional designers, and subject matter experts the means to create e-learning content more efficiently. The primary business problem the LCMS solves is creating appropriate content in a specific amount of time to meet the needs of individual learners or groups of learners. Rather than developing entire courses and adapting them to multiple audiences, instructional designers create re-usable content chunks and make them available to course developers throughout the organization. This eliminates duplicate development efforts and allows for the rapid assembly of customised content. Since the very first work in the field of LCMS, the principal goals were set as follows: adaptation (to learners), genericity (rather than fixed pre-composition) and scalability (industrial production without

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 13–18.
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mmeybodi@aut.ac.ir

proportional cost). An answer can be found with these three goals using the concept of pedagogical component. This concept has been largely studied and specific standards have been developed, for example: Dublin Core [8], LOM [9], SCORM [10], and ARIADNE [11]. All these works converge to the idea of a "learning object" which is comprised of course content and descriptive metadata (containing generic information such as authors, type of media used, semantic information such as pedagogical objectives, an assessment tool that measures whether or not the goal was achieved, and a description of the content). These standards allow the definition of platforms of learning-resource sharing, thus supporting the creation of a collective intelligence [3]. However, these standards do not fully take into account the semantics of the components and do not precisely describe the composition of the learning objects.

Hypermedia systems also address the issue of adaptation to end-users. Adaptive hypermedia learning systems use the results of the research undertaken in the field of Intelligent Tutoring Systems (ITS) and of the hypermedia [12], maintaining the strengths and mitigating the weaknesses of each approach.

ITS-style aims at replacing teachers with intelligent computer programs that automatically select and sequence learning objects for students. Also, ITS control the overall process of training. This global control forces the authors to define courses completely and dedicate them to a very limited public. This will cause learners to feel very constrained. The hypermedia exploits the multi-media nature of the resources. They propose, then, to free learners from the navigation during the course. The major disadvantage is that it would be impossible to control the process of training. These two approaches are extreme. The adaptive hypermedia learning systems try to define the medium between constraining users that is limited to actions necessary to achieve teaching objectives and the freedom of learning. InterBook [13], one of the first examples of adaptive hypermedia, is dedicated to computer programming training. It proposes navigation within a course using adaptive annotations showing the level evaluated for each target: "ready for training", "recommended", "not ready". It introduces a domain model (ELM-ART) [3]. Multibook [14] concentrates on user adaptativity in terms of media. It proposes user models of four dimensions (teaching goal, asset and level, method of training, and type of contents). These systems have good functionalities, but this approach is difficult to scale.

III. Pedagogical Model

This section presents the general architecture of our system. It is based on a reference model for the adaptive hypermedia application: AHAM (for Adaptive Hypermedia Application Model) [15], an extension of the Dexter hypermedia reference model. The division into a domain model (DM), a user model (UM), and a pedagogical-activity model (PAM) (including their constructors) provides a clear separation of concerns when developing an adaptive hypermedia application. To present our approach, we illustrate in Fig.1 the three levels of modeling we have defined.

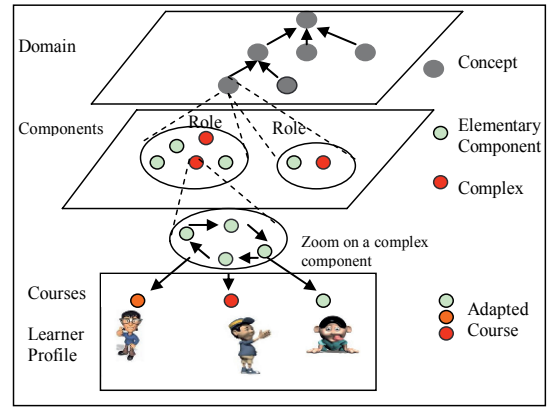


Fig. 1. Modeling levels

We have distinguished two main types of activities: synchronous and asynchronous activities. For each of these categories we proposed some tools for different types of pedagogical activities [16] (See Table I).

TABLE I
Activities Types

Synchronous works	Live course, practical work, tutorials, …	
Asynchronous works	Activities	Associated authors' tools
	Lecture Notes	Chapter, glossary, references, …
	Exercises	MCQs, Puzzle, …
	Case study,	Project, simulator, …

We summarize in Fig. 2 the architecture required in the system to construct pedagogical activities adapted to a user. The e-learning platform manages the user's profile and is able to communicate with the content to adapt its presentation and to receive information about the user actions, answers, behaviour and results. The creation of author tools automate and simplify the creation of multimedia pedagogical activities that are in progress.

mmeybodi@aut.ac.ir

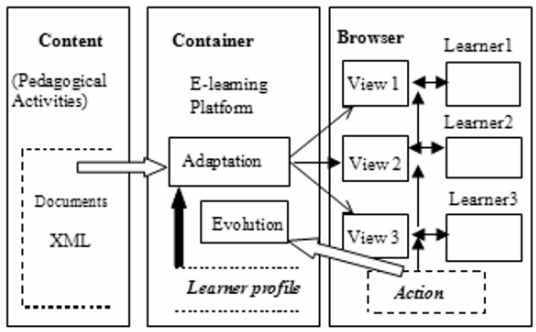


Fig. 2. Construction of pedagogical activity adapted to a user

The Domain Model

We distinguish between different logical levels: the upper level (abstract) that contains the domain concepts organized as graphs and the lower level that contains course metadata (expressed by XML [17] documents). The domain model is defined statically by a system administrator. It is composed of a set of concepts linked in several ways. We propose to use simple relationships such as generic/specific and synonymy to simplify the task of the system administrator. An important point in designing such a model is to choose an adequate formalism for its representation. We have chosen to use a Graphical Description (GD) (see Fig. 3). GD is viewed as the core of knowledge representation systems [18]. The interest of this representation is that it offers a good balance between simplicity and expressivity. Additionally, it offers some reasoning such as automatic concept classification which is very important in our approach. We use GD to represent knowledge at different levels: the domain concepts level and the components level. The main advantages of this approach are to supply pedagogical help at authoring time, to facilitate the search of components using a high-level query language, and to simplify adding new components by providing possible relationships between the newly added components and the existing ones.

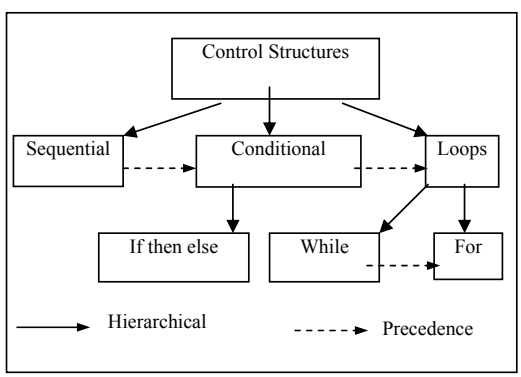


Fig. 3. Graphical Description

The User Model

Adaptive learning systems may adapt to the learners experience, knowledge, goals, or preferences [3]. We have considered the last three aspects in the design of our user model. The user model is a multi-layered overlay model [19][20] which contains individual information about each learner. Some of this information is given statically by the user (e.g. his/her graphical preferences) while some others can be captured or modified dynamically by analyzing his/her behaviour (e.g. his/her level relative to the domain concepts). For each learner, we maintain an evaluation of his/her level relative to each domain concept (we use a real number in the interval [0, 1]; 1 denotes perfect knowledge of the concept). We have also taken into consideration, the information about the result of evaluation on each concept. If we have no information about the user, stereotypes are used.

The Pedagogical Activities Model

We focus on the pedagogical activities model which is the core of the course authoring process. This section will successively present the pedagogy component and the complex component definition, the set of component constructors and their semantics, and finally, a description of the authoring and the delivering tasks (see Fig. 4).

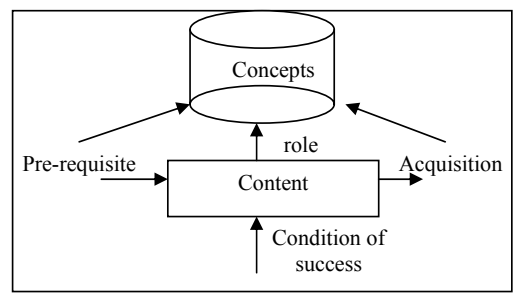


Fig. 4. A pedagogical activities model

A. Pedagogical components: a component includes content (URL of a Web resource provided by the author of the component) and is described by the metadata (represented in XML including LOM), including the description of its contents (list of domain concepts which are present in the component), its input conditions (the prerequisites), its exit (acquired concepts when the component was read successfully by the learner) and its condition of success (see Figure 4). It should be noted that the component granularity is fixed by its author and that there are no constraints on the content of a component even if a fine granularity will imply a better re-use of the component. Below, we describe the different relationships in the pedagogical activities model:

- A prerequisite relationship is a weighted relation between one component and one domain concept.
- An acquisition relationship is a weighted relation between

mmeybodi@aut.ac.ir

one component and one domain concept.

- A role is a relation between one component and a domain concept. It means that the component develops one or several aspects of the concept.
- A condition of success is a boolean condition taking into account observations about the learner like the time he/she takes to browse the course, his/her evaluation results if any, and so forth.

A component can be *elementary* (atomic) or *complex* (structured). It is related to a concept by specifying the role it plays in this concept. There are various roles (e.g., introduction, definition, evaluation, demonstration, application, experimentation, and example). A component can play several roles in a concept and it can be related to several concepts. A course actually followed by a learner corresponds to the instantiation of a component according to his/her profile (see Fig. 1).

B. Complex pedagogical components: a complex component is a directed graph whose nodes represent elementary or structured components. The arcs represent a crossing condition [21]. A course then becomes a set of components interconnected by didactic relations making it possible to keep coherence, to define the order of the topics and to adapt the course (see Fig. 5) with K: Knowledge Unit.

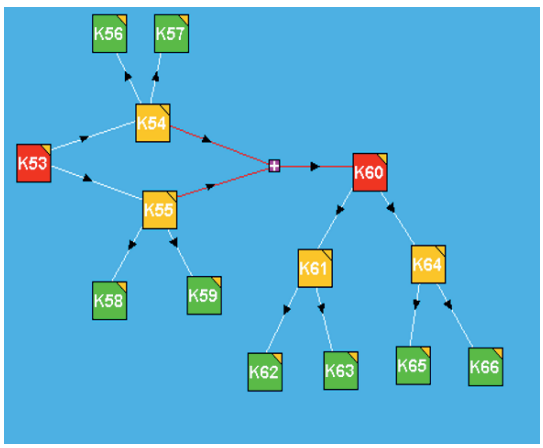


Fig. 5. Didactic relations

This composition is obtained by applying operators of composition on learning components. Before introducing component constructors, we present the constraints among components.

C. Dependency constraints

Some components can be strongly connected by dependency constraints. We define two types of constraints:

(i) Consequence-effect relationship (Ki → Kj): Kj is the effect of Ki ;
(ii) Achievement relationship (Ki ← Kj): In order to achieve Kj, it is necessary that Ki happens.

*D. Component constructors: w*e formalized different operators of composition allowing the building (possibly recursively) of a complex component starting from elementary components (or of complex components in the recursive case) [22]:

- Temporal constructors produce mandatory sequences or concurrent components.
- Logical constructors produce expressions of components that can be implemented with temporal constructors.

At the conceptual level, the logical constructors express the need for composing without specifying a total order among components. This means that on the operational level, they can be implemented using different total orders compatible with the construction expression. For each expression of components, we will, thus, have declarative semantics defined by the formal specification and operational semantics defined by a particular implementation. The constructors ensure some properties (commutativity, associativity, and distributivity). From these properties we can deduce equivalent expressions.

In order to formalize the production of courses process, we need to introduce two notions: class of equivalence and canonical form.

Class of equivalence definition

A class of equivalence is a generic expression giving place to equivalent expressions by application of the properties of the constructors. When an author creates a complex component, he/she has the possibility of writing it with a generic expression. The system must then check the coherence of the expression and breaks it up in order to make it irreducible.

Canonical form definition

A canonical form is an irreducible expression to which we cannot apply any property of the constructors. It allows a single implementation. An expression reduced to a sequence of atomic components is a canonical form. A set of canonical forms resulting from the same expression represents various possible views of this one.

Let's suppose we want to define a complex component describing a concept "A" with an introduction, an example, and an evaluation. K1, K2, K3 are components already stored in the component base. K1 and K2 are two possible definitions of concept A, while K3 is an example. So, we can define our complex component using this expression: ((K1 or K2) and K3). From this expression we can generate several derived expressions that represent possible scenarios.

E. Semantics of the constructors: when the components are composed, it is important to automatically process the new entries and exits of the resulting component.

F. Authoring and delivering processes: we distinguish two main processes: the authoring process which allows adding new components and the delivery process which allows selecting and adapting a course to a specific learner.

During the conception of an adapted course, the following main phases can be identified (see Fig. 6):

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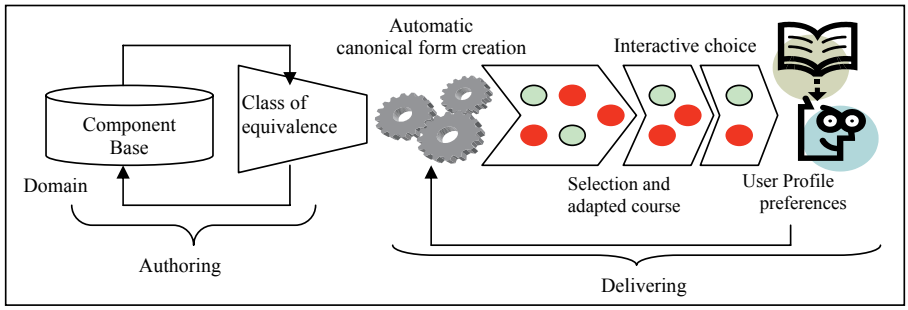


Fig. 6. From authoring to delivering

The authoring functionality use-cases:

- Addition of an elementary component. The new component is stored in the component base;
- Design of a complex component by submitting a complex expression which corresponds to a class of equivalence;
- Search a component for a specific objective expressed by a conjunction of domain concepts. The system searches if an existing component will satisfy the objective. A component satisfies the objective if its acquisitions are a superset of the objective. If the search fails, the author can create a new component satisfying the objective by re-using existing components (he/she can use the search tool to select components enforcing a lesser objective).

The delivering phase

A set of canonical forms is generated from the class of equivalence. At this step, we have several possible scenarios and we have to choose those which are best for the learner profile and preferences. The next step consists of removing all canonical forms that do not satisfy the learner goal, profile, and preferences.

If after the last step several canonical forms still correspond to the user profile, we can leave the final choice to the user in an interactive way.

IV. Implementation

In order to validate and evaluate our model, an implementation of this model was realized by the development of a training help application for an educational hypermedia for the training of the basic concepts of the Arabic language (HyperMadrassa System). HyperMadrassa is intended for basic concepts training of the Arabic language taught to the learners' pupils at the primary school of the educational system. To avoid any unspecified heterogeneity in the teaching of this very sensitive matter, the educational hypermedia reflects perfectly the official course approved by the Algerian Ministry of Education. Following, some interfaces and scenarios of the developed system are shown according to our model.

A. Access to HyperMadrassa

The *HyperMadrassa* application homepage (Fig. 7) allows having access windows. The learner is completely guided by the voice to direct him to choose (by a mouse click) one of the two following options:

- Book: to visualize the book of the first year learning.
- Learner: to choose the level of the learner (Fig. 7: beginner, intermediate, or good level).



Fig. 7. HyperMadrassa homepage

Learner's Interface

Two interfaces are developed according to the level of the learner as a beginner (Fig. 8) or a specialist (Fig. 9).



Fig. 8. Beginner interface



Fig. 9. Specialist interface

mmeybodi@aut.ac.ir

Through these interfaces, the learner chooses the starting concept. If the learner is a beginner and the chosen concept differs from, for example, letters (case of HyperMadrassa system), the system shows an advice (Fig. 9).

B. Training scenario

Once the beginner has chosen a course, the "Course Node" interface is presented to him/her (Fig. 10).

Figure 10: Course presentation



This page is composed of:

- Navigation tools: following node, previous node or back to homepage;
- Course page;
- Links to the top that allow access to the different concepts. If the learner clicks on one of these links without finishing the course, the system interferes by displaying the message "Advice".

C. Learner evaluation: "Exercise Node"

The exercise is presented as multiple-choice questions. The learner crosses of the right answers and validates his/her choice. According to the correctness of the answers, a message is displayed.

V. Conclusion

In this paper we have presented a pedagogical model based on a three-layer model. The model allows the description of the domains, the users and the components. The component model is the main part of our proposal. Components are described by metadata which combine their semantics (prerequisites, acquisitions and roles). Elementary components can be combined using constructors using a formal definition. By using these models, the system is able to assist the authoring process with a search tool and to offer an adaptive delivery of courses. The preliminary tests of HyperMadrassa system have improved their adequation to the initial specification of our model. An improvement of the system could be the integration of a cooperative model [23] including several learners and an instructor.

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mmeybodi@aut.ac.ir

Web Laboratory Experiences for E-Learning: The Michelson Interferometer

R. RESTREPO, D. ARISTIZÁBAL, A. MONTOYA, JEAN P. JIMÉNEZ H., PEDRO TORRES

Escuela de Física, Universidad Nacional de Colombia sede Medellín,
Medellín, COLOMBIA
A.A. 3840
amontoya@unalmed.edu.co

ABSTRACT

This paper describes the design and the implementation of software-hardware solution that allow Web laboratory experiences with the Michelson Interferometer. The hardware has a TINI (Tiny InterNet Interfaces), a control system given by a PIC microcontroller and a IP camera. The software was implemented with JAVA and the operating system was LINUX. It´s possible with this system to teach the principles and functionalities of the Michelson Interferometer via Web. The idea is that students of remote places can be use laboratory equipment using the Web.

KEYWORDS: E-Learning, TIC, Michelson Interferometer , Monitoring and Control via Web, TINI.

I. INTRODUCTION

This paper describes a hardware-software platform for monitoring and controling via Web a laboratory equipment, because this experiences are not possible on Schools of higher costs of the equipment . It was implemented using new technologies in electronics, such as Embedded Maxim-Dallas microcontroller TINI, and programming languages like JAVA of Sun Microsystems. The TINI Microcontroller is the heart of the system, can be programmed in JAVA, C++ and Assembler, allows the use of novel communication protocols and the cost is low; it is possible to be said that it is the smallest server of this time [1],[2],[3].

The growth of Internet has motivated the use of systems that use this great network for their operation. The new devices and their uses are being incorporated to take advantage of the opportunities given by the global communications [4],[5]. The network allow that the new technological developments fulfill the objective to make the life easiest for the people. The developed platform lays in this direction, since it makes possible that very expensive equipment is used so much for scientific developments as for educative aims, from any site of the planet that is connected to Internet.

This experiment allows to the remote students, using elearnig, obtaing the objectives:

- To explain the interference phenomenon.
- Known the displacement the movable mirror to measure the wavelength of the used laser light.
- Well-known the wavelength of the laser light used to measure the displacement of the movable mirror

II. MATERIALS AND METHODS

The work was divided in two great areas. First the development of the hardware: design and implementation of the complementary electronics to connect the TINI server and the PIC Controller; second, the development of software: analysis, design and implementation of the programs for Web monitoring and controling for the equipment, as example de Michelson Interferometer but the plataform can be used with other experiments and other type of the laboratory equipment.

A. Hardware

1.TINI

This embedded small server (a 67 mm x 48 mm) is developed by Maxim-Dallas, view figure 1. One of the most important characteristics of this microcontroller is the compatibility with some of

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the most important communication protocols such as TCP/IP, serial (RS-232), 1-Wire, CAN (Controller Area Network), [1], [2], [3]. It has a 1 MB flash memory to record applications and RAM of 512 Kb. A very useful function of this embedded system it is the use as bridge for the devices that do not have connection to Internet, The TINI server can be supervised and controlled from any Web site remotely

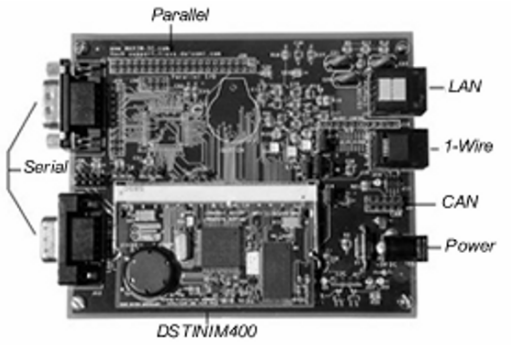


Figure 1. TINI Server (DSTINIs400 socket and DSTINIm400 board)

The designed platform use the serial communication of the TINI for the communication with the control system (PIC 16F87X Microcontroller). The LAN port of the TINI was used for connection between the TINI and an application Server

2. PIC16F873A

Low cost Microchip® Microcontroller family 16F87X, is the controller for the Michelson Interferometer it is function is to move the Interferometer, this PIC has:

- FLASH memory: 4K x words, 14 bits,
- RAM: 192 bytes
- EEPROM memory: 128 bytes, that allowing to program it with an application that manipulates the data.
- It has the hardware USART that allows ending and receiving information for the serial communication protocol RS-232.

3. IPCamera

The IP Camera is used for monitoring the system visually via Web. The Network Camera Axis 2100, it is allow the visualization through Internet using a Java applet. The camera has a rate of 10 frames/second.

4. Test equipment

To tes the platform was connected the TINI and the PIC with the Michelson Interferometer. The next is a basic description of the Interometer functionality.

– Michelson Interferometer

It is a interferometric system that uses the division by amplitude of the beam of originating light of the source through beams splitter, see figure 2, dividing it in two parts, using different ways before interfering. The light source is a laser (coherent light) so that a pattern of interference strips was generated on the screen of the experimental assembly. The experiment consists of micrometric moving the movable mirror of the interferometer, in such a way that in the interferometric pattern on the screen a gap between the dark strips and shiny is observed. In individual, when one goes of a shining center to another brilliant (happening through the one dark) obtains that the displacement D made by the movable mirror of the interferometer is given by the equation (1), [6], where N represents the number of changes between centers shining and λ_0 the wavelength in the emptiness of the used laser light.

$$D = N\frac{\lambda_0}{2} \qquad (1)$$

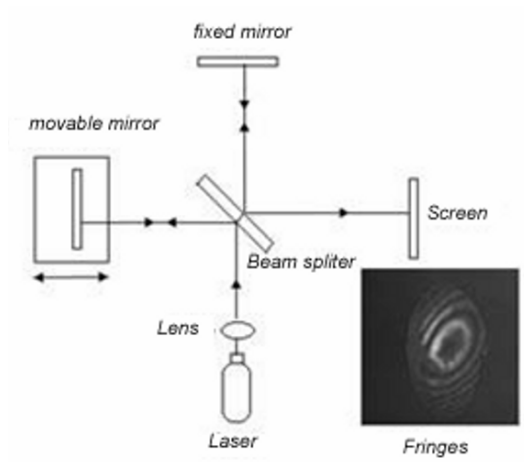


Figure. 2. Michelson Interferometer Diagram and Interference pattern..

.- Submicrometric positioner

This is the element used to move the mirror of the interferometer is an actuator model AD-30 with its source controller, manufacturing for Newport

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Corporation, see figure 3, that allows to make submicrometric displacements of 40 nm.



Figure 3. Driver Controller Model ESA-CSA with the actuator.

B. Software

The Software for the communication process (monitoring and control) was developed using the language JAVA of Sun Microsystems [7], [8] and JSP (Java Server Pages), and TOMCAT like container of applications JSP and servlets [9]. The IDE (Integrated Development Environment) used was Netbeans 5,0 of Sun Microsystems. Everything was developed to execute itself in LINUX like operating system. The software is of free distribution. One of the special characteristics of designed software, is that it was carefully used the powerful properties of the POO (Object-oriented programming), in addition to the serialization contributed by JAVA.

III. RESULTS

A. The system

The system is a set of elements that allow the communication between a Web user with the application executed on the application server TOMCAT. This application is connected with the TINI, the TINI send the orders to the device that controls, in this case, the positioning of the movable mirror of the interferometer, and to receive the answer to this request as it is outlined. See figure 4. Simultaneously the process it is monitoring by the IP camera.

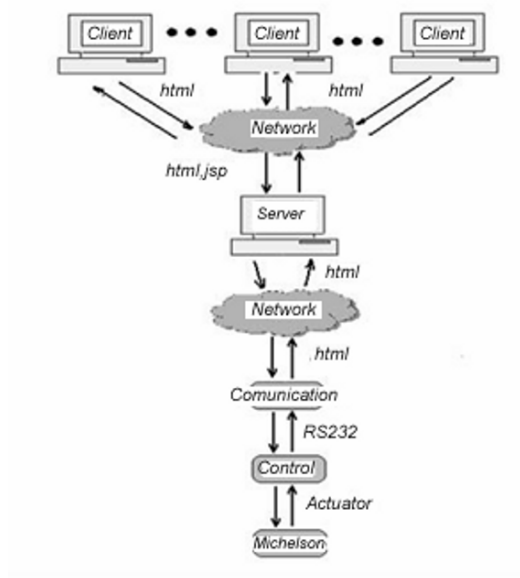


Figure 4. Plataform Diagram.

B. Hardware description

The stages of the developed hardware include, among others, adaptation of the TINI to manage and connect it to the general system correctly, and the system of control of positioning of the movable mirror of the interferometer.

1. TINI adaptation

The design used a regulated source of DC voltage, provide the necessary energy for TINI system as for the fan that was added to avoid overheats and, therefore, to protect the processor voltage (DSTINIm400). The TINI and the regulated source were contained in an acrylic box properly designed, fulfilling certain necessities, among them, the availability of all the ports possible with no need to expose dangerously the integrity of the system, to see figure 5.

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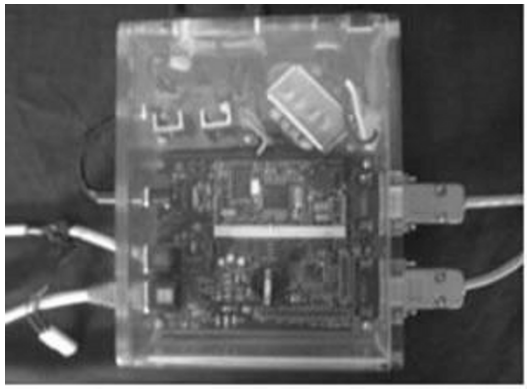


Figure 5. Protection Box for the TINI

2. Actuator control system

The system for control consists of a power supply, a PIC16F83A, a set of LED, a Max-RS232 controller, a converter D/A DAC0808 and a opto-electronic sensor. The developed device makes the connection between the SERVER-TINI and the user. Figure 6 corresponds to a photo of the assembly of the interferometric system and the control system.

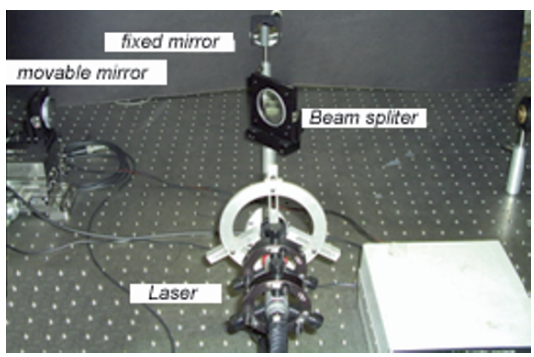


Figure 6. Michelson Interferometer

C. Developed Software[†]

The system is a set of classes located in the applications server TOMCAT and another set located in the TINI. These are grouped in the following packages: *communication, information, drawing, handling of data and time*.

The communication package contains the classes responsible for the communication between the devices. These appear as internal classes in a single called class *Aplicacion.java* and are: *Servidor.java*, *Aplicacion.java* y *ConexionTini.java*. *Aplicacion.java is responsible to open and to form the port for serial communication, also to put the server in an infinite request loop be processed by each user*. *Servidor.java* is responsible "to listen to" the requests that arrive by the port of communication 2005, to be given to the class *ConexionTini*. *ConexionTini.java is responsible to process the request of the user; this is sent as a set of bytes to be interpreted by the PIC to conduct the operation*. The class also takes care of receiving the results sent by the PIC and to pack them for passing to the user of a legible form. This class create the bridge for the connection with the Tomcat container and the PIC, in addition to being the channel by where the information from a place takes to another one.

In the other packages, as their name indicates it, the classes of information shipment are implemented, obtaining of the values associated to the wavelength of the used laser light, handling of data and run times and answer.

D. Functionality description

The system is awaiting requests of some remote user who enters, via Internet, to the application by means of a public direction IP, unfolding a window that asks for the access key (user name and password). Once this request is accepted, appears the WEB page illustrated in the fig 7 that it has, in its left side, a set of options; here also the optics laboratory visualization, specifically the interferometric system. After the user has selected some of the options, the order via WEB to the TINI is transmitted, that will as well transmit the message to the control system (the PIC), executing the action and returning the obtained values.



Figure 7. Screen capture of the monitoring and control of the Michelson Interferometer through IP camera .

[†] Information about the source code,classes and hardware use, can be obtained writing to amontoya@unalmed.edu.co.

mmeybodi@aut.ac.ir

IV. CONCLUSION

One of the most important results of this work is the use of a new technology as the microcontroller TINI and it is multiple services of communication protocols. The great adaptability of the developed hardware-software system allows to its applicability for monitoring and remote control of other physical systems on the laboratory, allowing the development of remote laboratories, it is possible to do academic instruction via the Internet or the Intranet (e-learning) for other experiments and higher cost equipment. The system was developed using free software tools, which lower the development cost substantially.

Systems like these can be used so that universities with better laboratory equipment, and other institutions that have less resources. This accelerates the development of the poor countries and help to generalize the education and the research in other institutions. This system can be duplicated, used or adapted for other experiments and other possibilities.

VI. GRATEFULNESS

This work was partially financed by DIME (National University Colombia Medellín, code 30802945) and for COLCIENCIAS, project code 1118-330-18905. All the rights belong to the National University of Colombia.

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mmeybodi@aut.ac.ir

Development and Implementation of an Information Server for Web-based Education in Astronomy

A. Alegre, J. Estrada, B. Coalson, A. Milshteyn, H. Boussalis, and C. Liu
Department of Electrical and Computer Engineering
California State University, Los Angeles
5151 State University Drive
Los Angeles, CA 90032 USA

Abstract **— This paper focuses on the development of a high-performance information server for web-based education. An innovative model of software architecture is provided to effectively utilize the computational power of a parallel server platform for efficient, on-demand astronomical image browsing through the Internet.**

Our previous research revealed the demand for astronomical image browsing raised by various communities engaged in educational and research activities. Additionally, we have characterized network performance under different levels of activity and identified techniques for efficient image transmission over the Internet. Based on our findings, we have developed a parallel server which will handle an arbitrary (typically large) number of simultaneous requests for astronomical image files from distributed clients. The server is capable of disseminating data at different transmission rates to accommodate the various network bandwidth restrictions, real-time display requirements, and/or image resolution requirements of different communities.

In our design, a tuple space programming paradigm is used to enable parallel processing of the image browsing requests. This architectural model supports automatic load balancing to fully utilize the computational power provided by the parallel server. Additionally, a hashing algorithm is used for fast look-up of astronomical image files in the database. Since different image resolutions and transmission rates may be required, multiple worker processes (known as threads) are employed to perform progressive, on-demand image decompression and transmission using a wavelet-based transformation algorithm. This approach facilitates efficient use of system processing and communication resources while providing the flexibility to serve a diverse clientele. The various service parameters can be explicitly defined by the client or implicitly analyzed by a controller thread on the server side, thus providing the "best effort delivery" given realistic constraints.

Keywords — Information server, tuple space parallel programming paradigm, hyperthreading architecture, space-science education

I. Introduction

The National Aeronautics and Space Administration (NASA) in 1994 provided funding to establish the Structures, Pointing, and Control Engineering Laboratory (SPACE Lab) at California State University, Los Angeles (CSULA). The goal of this laboratory is to design and fabricate platforms that resemble the complex dynamic behavior of a segmented space telescope, the James Webb Space Telescope (JWST) [1], and its components. Since its inception, the laboratory has made efforts to use the most current computer technologies to develop a prototype information server for the purpose of disseminating multimedia files related to the project. The target audience includes communities ranging from professional and amateur space scientists to students, educators, and the general public. Such efforts meet NASA's mission to encourage space exploration and research through education. To promote the awareness of NASA's missions, current digital technologies can be used to facilitate the establishment of networks not only for scientists and engineers of today, but for generations to come.

This paper focuses on the development and implementation of an Aerospace Information Server to support efficient, on-demand information dissemination. The SPACE Lab has endeavored in the development of a parallel tuple space server (Aerospace Information Server, AIS) for web-based education. Specifically, the design is focused on, but not restricted to, astronomical image browsing. Connection to the server will be Internet-based. As such, the server must be able to cope with multiple simultaneous image browsing requests. Additionally, the AIS must be able to support various data transfer rates due to network bandwidth restriction, real-time display requirements, and different image resolutions as dictated by the diverse communities accessing the server. In order to implement these requirements and maintain the server's speed and efficiency, various technologies have been implemented into the server as listed below:

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1. Tuple space programming paradigm for parallel processing and automatic load balancing [7].
2. Search algorithms utilizing a hash table for expedited access to database files [5].
3. Wavelet-based image transformation algorithms for progressive image compression/decompression, and image transmission [14], [15].

The paper is organized as follows: Section 2 introduces the hardware of the server. Section 3 describes the software architecture of the server system. Section 4 details the technologies employed. Section 5 describes the implementation issues. Section 6 concludes the paper.

II. System Description of the Aerospace Information Server

In order to implement the key technologies stated above and maintain real-time performance, a state-of-the-art computer system must be utilized. The Dell PowerEdge 1855 Blade Server, as shown in Fig. 1, was selected as the foundation for the AIS. The modular nature of this system facilitates scalability while minimizing power consumption and physical space required. Multiple server blades are housed in a chassis that contains power supplies, communication modules, and cooling fans shared by the entire system. Each server blade contains two dual-core 64-bit Xeon Processors with up to 16 GB of DDR2 shared memory. The two Xeon processors are interconnected by a dual front-side bus running at 667 MHz (see Fig. 2). Each of the cores is outfitted with its own L1 Cache, while the two cores on each chip share a L2 Cache (2 Mb). All four cores have shared access to main memory. The Xeon processor supports Hyper-Threading technology, and hence, two software threads can be established simultaneously in each core of the processor [10].

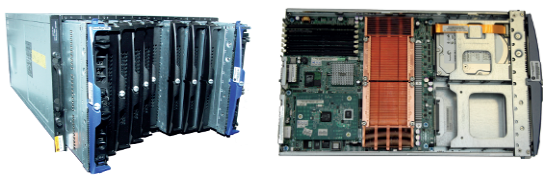


Fig 1. Dell Poweredge 1855 Blade Server chassis (left) and single blade server (right)

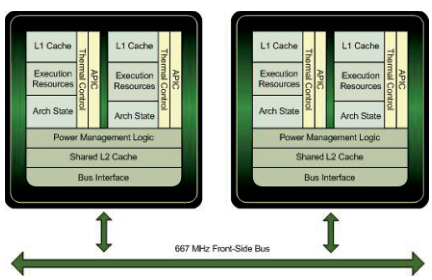


Fig. 2. Two Intel dual-core Xeon processors on a single blade server

III. Software Architecture

The Dell PowerEdge 1855 Blade Server offers many unique architectural features that optimize system performance, making it the ideal platform for the AIS. Dual-Core and Hyper-Threading technologies are used to implement parallelism and share memory spaces within the server. The software architecture of the AIS was developed to exploit these features and optimize performance. Figure 3 displays a flowchart of the AIS. Each dual-core Xeon processor contains four virtual software threads. The threads are assigned and perform individual tasks depending on their role. Three of these threads are designated as Worker threads and one as a Controller thread. The Controller thread is responsible for initially connecting to and receiving requests from a client. The Controller thread also manages the tuple space, which stores a pool of requests made by clients. The three Worker threads operate in parallel and handle client requests (i.e. searching the server's database for the corresponding image to a specific image query). Upon completing their assigned tasks, Worker threads reconnect to the client in order to communicate the results. A more detailed view of information flow within the AIS will be discussed in the following sections.

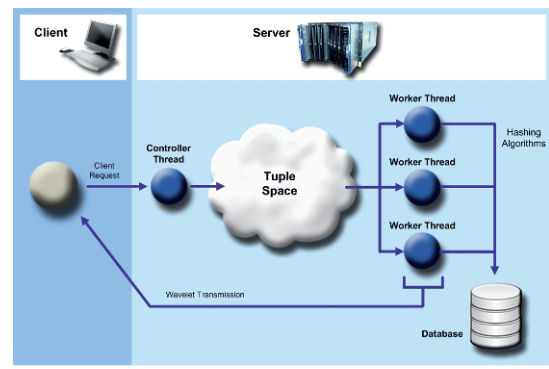


Fig 3. Flowchart of Aerospace Information Server

IV. Technologies Employed

Tuple space utilizes a content-associative memory archetype for parallel and distributed systems. The technology specifies a depository space for tuples [8]. Through this approach, multiple processing units are able to retrieve tasks from a common pool of requests. Whenever a Worker thread becomes available, it accesses the tuple space to retrieve a request and process it accordingly. In this way, automatic load balancing is realized among the threads.

A hashing algorithm is implemented within the server for high-performance database access [5]. The technology applies an algorithm to a key (in this case, the file name) to produce a numeric value. This value is then mapped to the hard-drive address of a stored image. The collection of all the key-address pairs comprises a hash table. The functional

mmeybodi@aut.ac.ir

programming allows for expedited access to database files by directly associating the name of the requested image with its location in physical memory. Thus, a thread needs only to calculate the hash number of the key and obtain the associated address to access the desired image file, rather than searching the entire database on a file-by-file basis.

Additionally, wavelet-based transformation algorithms are integrated into the system in order to progressively compress or decompress images on-demand [15]. Figure 4 illustrates the concept of the wavelet-based data transformation. In this figure, an image is capable of being divided into regions utilizing separable filters. The region sizes are inversely proportional to the desired image resolution of the user. When the desired resolution has been reached, a sample of the region is taken and transformed into a packet. The packets may then be transmitted and an image rebuilt by a user, based on the contents of the packets [14]. By offering the client the option of selecting a compression ratio based on individual use, only one high-resolution version of an image needs to be stored in the AIS database. This unique approach greatly reduces the amount of physical memory required to house the image library.

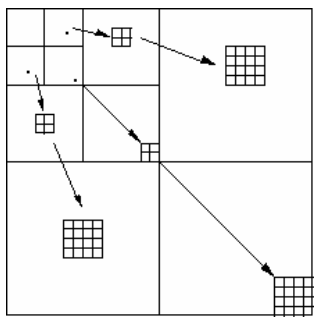


Fig. 4 A two-scale discrete wavelet decomposition

V. Implementation of the Aerospace Information Server

We have used the Hyper-Threading architecture to allow for the definition different roles among processor threads. These threads include a Controller and multiple Workers. This delegation of roles allows for efficient communication and task scheduling, as well as automatic processor load balancing.

A. Controller Thread

Initially, a client will explicitly input a request, including the desired name and resolution of the file, to AIS via a specialized graphical user interface (GUI). Note that such features could otherwise be specified by the Controller thread based on the client's communication constraints and image resolution requirements [2]. The GUI will also take note of the client's IP address and assign a port number for the client computer to listen to. A tuple is then generated using this information. Tuples used in the AIS adhere to the generalized structure shown below:

<File name, Resolution, IP address, Port number> (1)

Upon transmitting its request, the client will then disconnect from the server. However, the client will remain listening on one of its ports for a reconnection request made by the AIS. This process of connecting and disconnecting allows the AIS to gather more requests within a given timeframe. The server does not need to wait until the client's request has been fulfilled before it can take another request. Instead, the server is able to disconnect from the client and connect to a different client to obtain a new request.

The request tuple is then deposited to tuple space, which is continually monitored by the Controller thread. The tuple will remain there until a Worker thread is able to accommodate the request.

The tuple space region is located in the server's shared memory. Therefore, all Worker threads are able to access a common pool of requests at the same time. It is possible that a tuple can be accessed by more than one thread, causing misread data and incorrect results. Thus, in order to maintain the integrity of stored data, semaphores are used. Semaphores lock the memory location to a specific thread until it has finished its task [13]. Once completed, the thread relinquishes control of the shared memory region.

In our implementation, a semaphore is activated while the Controller thread is writing a request into tuple space. In this way, it is ensured that a Worker thread does not attempt to read the request prematurely. Semaphores are also placed on the Worker side for protecting the critical section of the shared memory space. When available, a Worker thread will access a request in tuple space and set a semaphore. This makes certain that the Controller thread is unable to overwrite that memory location. Additionally, the memory location is made unavailable to other Worker threads attempting to access the request.

B. Worker Threads

The role of the three Worker threads in the AIS is to search the database for the desired image. To minimize the time required to perform image searches, a hashing function is utilized. Hashing functions apply a reproducible algorithm to convert a data element, called a key, into a numerical representation of the data, called a hash number. The hash number is then mapped in a table to the memory location of the particular file. In the AIS, the file name is used as the key. When an image request arrives in tuple space, a Worker thread will apply the hashing function to the file name. The Worker then looks up the hash table entry for the resulting hash number and returns the corresponding memory address. This methodology allows AIS to advance directly to the location of the image rather than searching the entire database for the file. As such, the location of the image in physical memory does not matter anymore. By

mmeybodi@aut.ac.ir

utilizing hashing functions, the search time will remain the same regardless of the image's location in memory. Thus, overall system efficiency is raised.

A key metric for determining the efficiency of hashing functions is collision rate. Collisions occur when different hash keys produce the same hash number. Thus, multiple records must be stored at a single location in the hash table. To manage collisions, the hash table is organized into buckets. Each bucket number corresponds to a unique hash number. In the case that a collision occurs, a pointer to the memory address of the next image with that hash number is stored in the table. Using this approach, fast and efficient searches are preserved.

The Cyclic Redundancy Check, 32-bit (CRC-32) algorithm was chosen as the hash function used in the AIS. This function has many characteristics that suit it to this application. CRC-32 produces a 32-bit numerical output for each input, which is easily handled by the 32-bit registers of the AIS. A low collision rate of 0.03% [5] allows for efficient search implementation with large data sets. The function itself requires few calculations, further reducing system overhead and improving search time.

After the Worker thread has found the desired image in the server, it will then reestablish a connection to the client utilizing the IP address of the client and the port number that the client is listening to. Wavelet transformation is then used on a copy of the requested image. The image is broken down into digital components. Each component, or packet, takes a sample of the image portion it corresponds to. Depending on the client's initial resolution request, AIS will send a specific percentage of the total number of packets. Additionally, packet size may be altered to further fine-tune image decompression rates. Afterwards, the client reconstructs the image utilizing the received packets. The obtained image quality is directly proportional to the number of packets the client receives. For a high image quality, a large number of packets must be received to accurately reassemble the image. For lower quality images, the opposite holds true. Below are images showing various image qualities when differing numbers of packets are sent (Figs. 5 and 6).



Fig. 5 Original image of Linear Comet, Dec. 2001 (64 packets) [12]

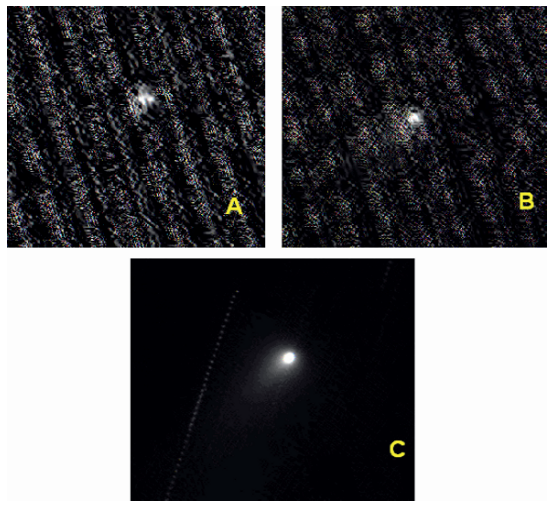


Fig. 6 Image reconstruction after A) 4 packets, B) 6 packets, and C) 32 packets received

VI. Concluding Remarks

This paper focuses on the development of the software architecture to support web-based astronomical image browsing. The architecture utilizes the unique features of the underlying server platform to optimize performance. Although the design of the Aerospace Information Server is primarily focused on research and education, the parallel server model can be generalized for other applications with similar features. Examples of this include pay-per-view movie multicasting, multimedia information streaming and distribution, and online gaming. Using the progressive compression and transmission paradigm of the AIS, only one high-quality media file would be needed to serve multiple requests with different requirements. The result is a fast, highly efficient parallel server capable of handling large loads effectively. The continued development of the AIS will include performance evaluation of the utilization of memory and hierarchical resources (i.e. cache memory) at the core and thread levels. Additionally, the Graphical User Interface on the client side will be expanded and will include image viewing features such as zooming, conversion, and selection.

Acknowledgement

This work was supported by NASA under Grant URC NCC 4158. Special thanks go to the faculty and students associated with the SPACE Laboratory.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Using Graphing Calculators for Teaching Advanced Calculus Courses

A. Y. Vaninsky,
Hostos Community College of The City University of New York
500 Grand Concourse,
Bronx, NY 10451 USA

Abstract - **It is suggested to extend using graphing calculators with symbolic calculations capabilities beyond the traditional framework of their applications. Among the new applications are evaluation of partial derivatives and the derivatives of composite functions, improper and repeated integrals, derivatives of the definite integrals with functional limits of integration, Laplace transforms, functional determinants, partial fractions etc. Such problems are typical for advanced calculus courses, and graphing calculator can serve as convenient alternative for more expensive and less available computer algebra systems like Mathematica, Maple, MatLab etc. The paper presents experience of the author in teaching advanced calculus courses at one of the colleges of New York City**.

I. Introduction.

This paper presents calculus tools available with graphing calculators that fall behind the traditional spheres of their applications and are useful in teaching and learning advanced calculus courses. These tools are not widely known or well described. Presented material is based on the author's experience of teaching calculus at one of the colleges of New York City. References regarding calculus or differential equations topics are available online via Google or, in printed form, in [1] or [2], respectively.

II. Basics of graphing calculators.

In this paper, we use the graphing calculator TI-89 because of its wide use in education. Its main features essential for the objectives of this paper are given below. Comprehensive description of its functionality may be found on the website [3]. The Texas Instruments Company (TI) developed the TI-89 in 1998. It has an LCD screen with advanced flash memory and TI-developed Advanced Mathematics Software. The major advantage of the TI-89 is its built-in Computer Algebra System (CAS): the calculator can evaluate algebraic expressions symbolically. The answer is displayed, as it would be written on paper. In 2004, a new version of TI-89 appeared in the market: the TI-89 Titanium.

Each alphanumeric key of the calculator usually performs three functions. The first function is given on a key, the second one requires that a yellow key "***2nd***" was pressed first, and the third function is performed after pressing a green diamond key "♦", or a pink "***alpha***" key. Operations of differentiation and integration are most important for the objectives of this paper. To perform them, the following sequences of keystrokes are required:

- Differentiation:

2nd	8	Function	,	Variable	,	Order	)

The differentiation sign is entered as a sequence of "***2nd***" and "***8***" keys. The order of the derivative is optional. If omitted, the first order is assumed by default. Example of evaluation of the second derivative of the function $y = sin(3x)$ is shown in fig.1.

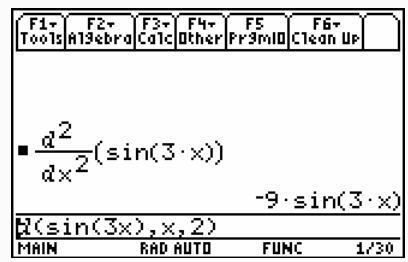


Fig. 1. Differentiation.

- Integration:

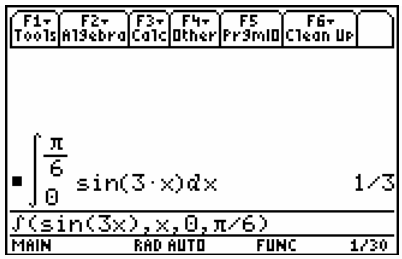
2nd	7	Function	,	Variable	,	Lower limit	,	Upper limit	)

The integration sign is entered as a sequence of "***2nd***" and "***7***" keys. The lower and upper limits of integration are optional. If omitted, indefinite integral is evaluated in a symbolic form. Example of evaluation of the definite and indefinite integrals of the function $y = sin(3x)$ are shown in fig.2a and 2b, respectively.

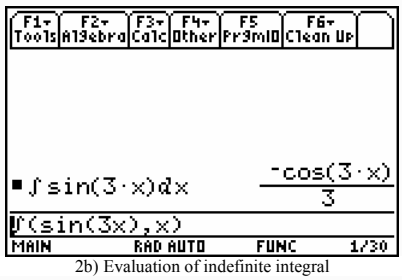
Improper integrals can be evaluated as well. Fig. 3a and 3b present evaluation of an improper integral with infinite upper limit of integration in two ways. The first way is direct evaluation using the ∞-symbol; the second way is evaluation of the limit value of the integral with the upper limit of integration approaching infinity. Recall that the ∞-symbol is entered as a combination of the "♦" (green diamond) and "***catalog***" keys, and the limit-symbol, as acombination of "***F3***" and "***3***" keys.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 29–34.
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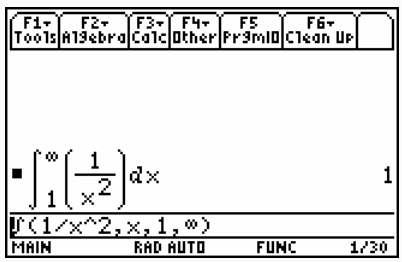


2a) Evaluation of the definite integral.

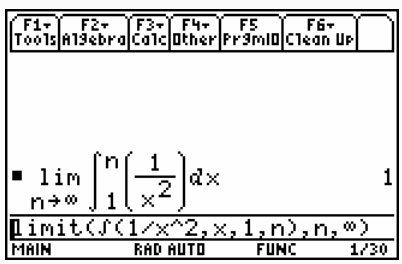


2b) Evaluation of indefinite integral

Fig. 2. Integration.



3a) Direct evaluation.



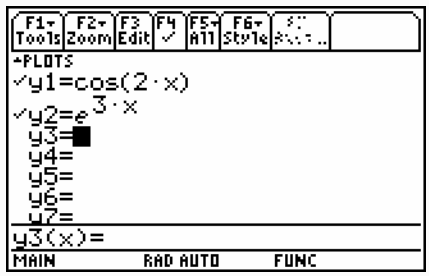
3b) Evaluation using a limit.

Fig. 3. Evaluation of improper integrals.

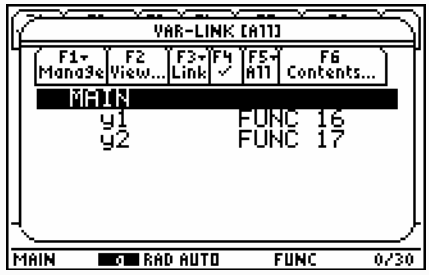
III. MAIN EXAMPLES.

A. Differentiation of a composition of functions

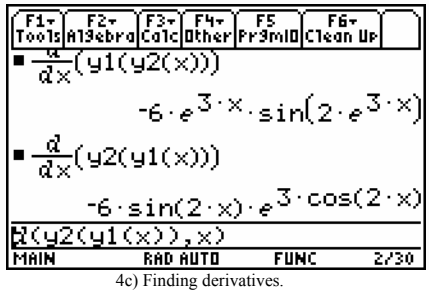
Functions are defined using the sequence of "♦" (green diamond) and "***F1***" keys. Access to the functions is provided by the ***var-link*** key command that corresponds to the combination of "***2nd***" and "**-**" keys. Fig. 4a, 4b, and 4c present an example of the composition of two functions $y1=\cos(2x)$ and $y2=e^{3x}$ and computation of their derivatives in different orders. This example demonstrates that composition is not commutative operation. Evaluation of higher derivatives and composition of three or more functions can be done in a similar way.



4a) Defining functions.



4b) Access to the functions.



4c) Finding derivatives.

Fig. 4. Differentiation of the composition of two functions.

B. Partial differentiation

If a function has two or more arguments, then differentiation can be performed by each of the variables (partial derivative). Fig 5 presents finding second partial derivative of the function $y=\sin(2x + y^2)$ by y.

C. Implicit partial differentiation

If a function is defined implicitly then a partial derivative can be evaluated by using a two-step procedure as shown below. At the first step, the partial derivative is calculated as a

mmeybodi@aut.ac.ir

term of an equation that is linear with regards to the derivative. At the second step, the partial derivative term is changed for a variable. Finally, the equation is solved for this variable. Fig. 6a and 6b present the procedure for a function $z(x,y)$ defined implicitly by equation $x^2 + y^2 + z(x,y)^2 = 1$. The obtained answer is $\partial z(x,y)/\partial y = -y/z(x,y)$ that is well-known in calculus. Higher derivatives can be evaluated similarly by applying this procedure two or several times.

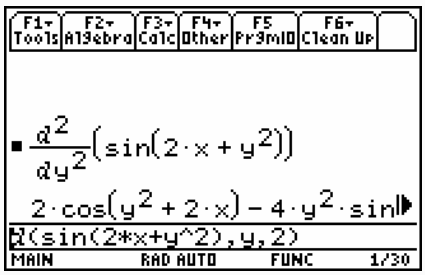
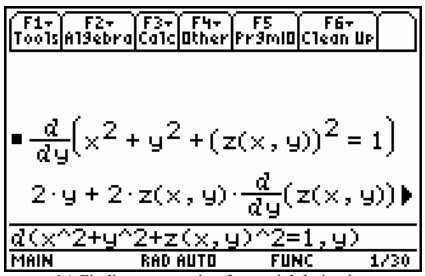
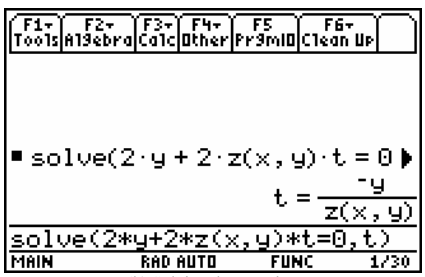


Fig. 5. Partial differentiation.



6a) Finding an equation for partial derivative.

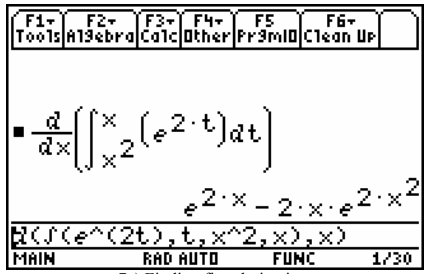


6b) Solving the equation.

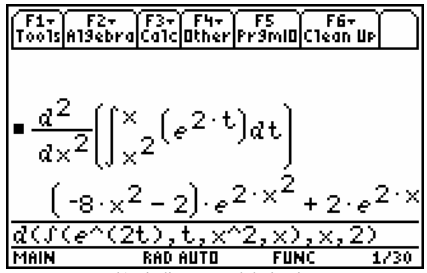
Fig. 6. Implicit partial differentiation.

D. Differentiation of integrals

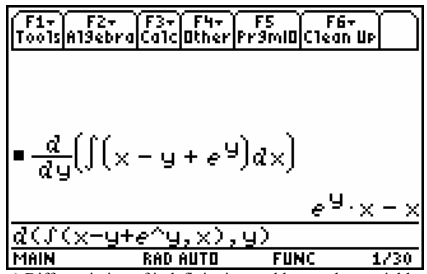
Differentiation of the definite integral by the upper limit of integration is referred to as The Fundamental Theorem of Calculus, Part 2. If differentiation is performed by the upper limit x, the problem is quite simple: the variable x should be just plugged into the integrand in place of the variable of integration. The situation is more complicated if either one or both limits of integration are functions of x or higher derivatives are required. Fig 7a and 7b present the evaluation of the first and second derivatives of the integral of $f(t)=e^{2t}$ from x^2 to x. Fig. 7c presents differentiation of indefinite integral by a variable that is not the variable of integration. The latter case is a typical part of the procedure frequently used for solving exact differential equations. In the figure, $f(x,y)= x - 2xy + e^y$, with integration performed by variable x, while differentiation, by variable y. The result is $\partial/\partial y[\int(x - 2xy + e^y)dx] = e^y \cdot x - x$, or $x(e^y - 1)$.



7a) Finding first derivative.



7b) Finding second derivative.



c) Differentiation of indefinite integral by another variable.

Fig. 7. Differentiation of integrals.

E. Finding convolution

Convolution of functions $f(x)$ and $g(x)$, both defined for $x \geq 0$, is an integral $\int g(x-t)f(t)dt = \int f(x-t)g(t)dt$ taken from $t=0$ to $t=x$. This integral, usually denoted as $f*g$, plays an important role in differential equations and applications. In particular, it determines reaction of a system that has an impulse response function $g(t)$ to the external forcing function $f(x)$. Fig. 8 represents finding convolution of $g(x)= e^x$ and $f(x)=\sin x$ in explicit form.

mmeybodi@aut.ac.ir

F. The Laplace transform

The Laplace transform is a conversion of a piecewise continuous function *f(t)* defined for $t \geq 0$ and growing no faster than exponential function into an image-function $F(s)= \int e^{-st} f(t)dt$, where the integral is taken from $t=0$ to infinity. Fig 9a and 9b represent an example of finding Laplace transforms of functions $f(x)=\sin x$ and $g(x)= e^x$. Calculating the integral

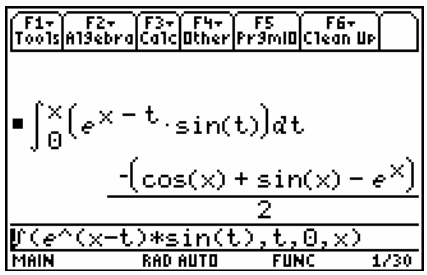
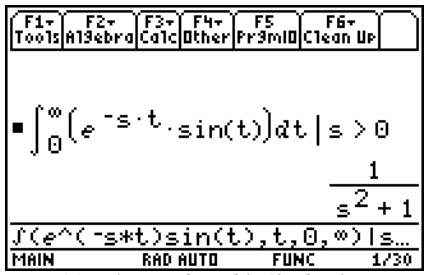


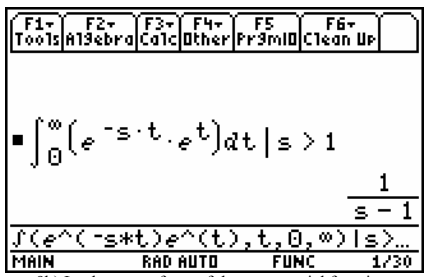
Fig. 8. Finding a convolution.

requires restrictions imposed on the variable *s*: it should be positive for $f(x)=\sin x$ and greater than 1 for $g(x)= e^x$. These conditions are introduced by typing a sequence "|s>0" or "|s>1" after the integral, respectively.

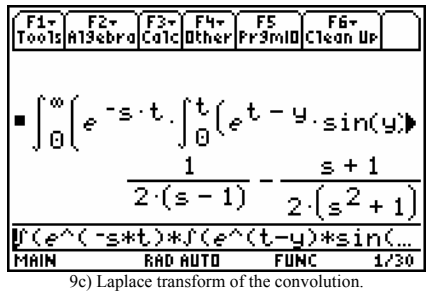
As known, the Laplace transform of a convolution equals to the product of the Laplace transforms of the two functions. Fig. 9c shows the Laplace transform of the convolution of the functions $f(x)=\sin x$ and $g(x)= e^x$. After simplifying the answer using the ***factor***-command, we get the product of the two transformations: $L\{\sin x\}=1/(s^2+1)$, $L\{e^x\}=1/(s-1)$, and $L\{\sin x * e^x\}=1/[(s-1)(s^2+1)]$, as shown in fig. 9d.



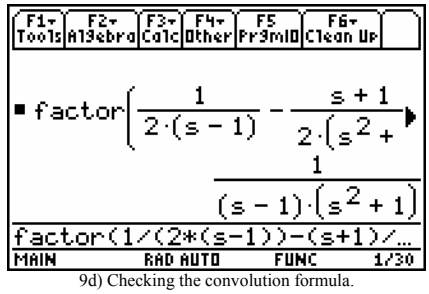
9a) Laplace transform of the Sine function.



9b) Laplace transform of the exponential function.



9c) Laplace transform of the convolution.



9d) Checking the convolution formula.

Fig. 9. Finding Laplace transforms.

G. Repeated integrals

Repeated integrals are frequently used for evaluation of the multiple integrals. Consider, for example, a problem of finding a mass of a lamina bounded by the graphs of the functions $f(x)= x$ and $g(x)= x^2$ that has a density function of $h(x,y)=e^{x+y}$. Fig. 10a presents the corresponding graph, and fig. 10b, result of computation. In this example, integration is performed repeatedly, firstly by *y* from x^2 to *x*, then by *x,* from 0 to 1.

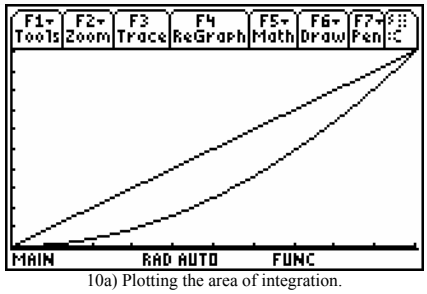
H. Finding partial fractions

As known, integral of any rational function may be evaluated as a sum of the integrals of partial fractions. There are four types of partial fractions. Usually, expansion of a given fraction into the sum of partial fractions is a time consuming problem. The command "***expand***" performs this task, as shown in fig. 11. It should be noted that graphing calculators are not always perfect in the expansion. Thus, author's TI-89 (version 1.00, 1998) failed to expand a fraction $1/(x^4+4)$ into two terms with quadratic denominators: $1/(x^4+4) = (x+2)/[8(x^2+2x+2)] + (-x+2)/[8(x^2-2x+2)]$

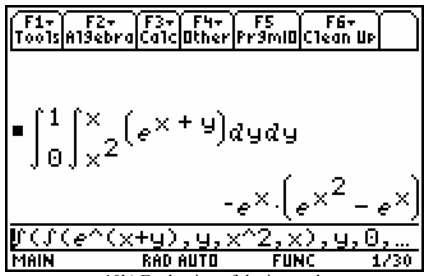
I. Graphing functions defined by series

Some types of differential equations may be solved in a form of power series or Fourier series form only. In such cases, it is important to obtain a graph of the solution. Graphing calculator available to the author does not allow operations with infinite series. Nevertheless, graphs of finite series could be plotted. Fig. 12a and 12b represent, respectively, a definition and a graph of a function defined as 10 first terms of the Fourier series $f(x)=\sum \cos(nx)/n^2$, summation by *n* from 1 to 10, $-\pi \leq x \leq \pi$.

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10a) Plotting the area of integration.



10b) Evaluation of the integral.

Fig. 10. Repeated integration.

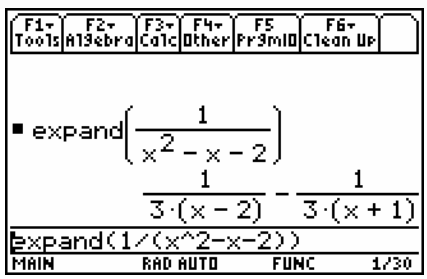
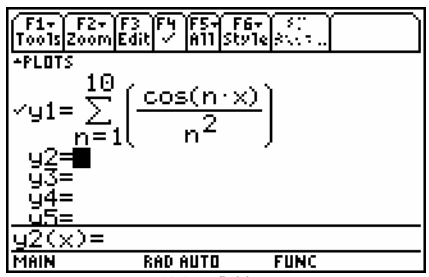


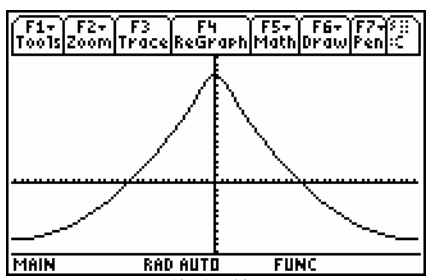
Fig. 11. Partial-fraction decomposition.

J. Wronskians

Wronskian is a functional determinant of order n that contains functions $y_1(x)$, $y_2(x)$, …, $y_n(x)$ in the first row, their derivatives in the second row, second derivatives in the third row etc up to the $(n-1)$-order derivatives in the n^{th} row. It is known that if the Wronskian of a set of particular solutions of a linear differential equation is not equal to 0 at least at one point, then these solutions are linearly independent and can be used for construction of the general solution. Graphing calculator provides a convenient tool for testing linear independence of particular solutions. To do this, one needs to define functions $y_1(x)$, $y_2(x)$, …, $y_n(x)$ and then evaluate the Wronskian using these functions and their derivatives. Fig. 13a and 13b represent the procedure for the case of two functions: $y1(x)=\sin(x)$, $y2(x)=\cos(x)$. A command for calculation of the determinant function is performed by pressing a sequence of "***2nd***", "***5***", "***4***", and "***2***" keys. Rows of the determinant are entered in brackets, and are separated by semicolons. In fig.13b, determinant $W(\sin(x), \cos(x))$= -1, so that functions $\sin(x)$ and $\cos(x)$ are linearly independent. It is easy to repeat calculations for another pair of functions: it is sufficient just to change the definitions of functions $y1(x)$ and $y2(x)$.

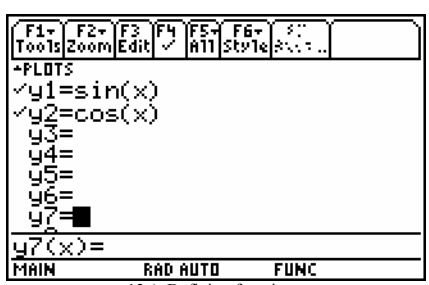


12a) Definition.

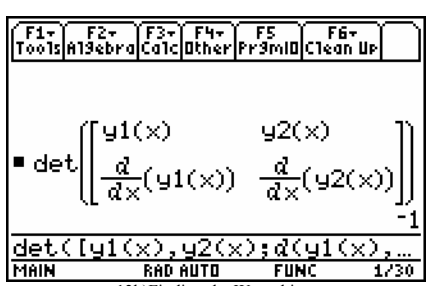


12b) Graphing.

Fig. 12. Functions defined by series.



13a) Defining functions.



13b)Finding the Wronskian.

Fig. 13. Evaluation of the Wronskian.

mmeybodi@aut.ac.ir

REMARKS

Using graphing calculators in advanced calculus courses allows focusing on statement of the problems and methods of their solution, rather than on performing calculations. Additional advantage of using Computer Algebra System (CAS) built-in into graphing calculators is entering formulas in a format different from that used in textbooks. This teaches students that the way of presenting formulas may change while keeping their mathematical content unchanged. Using graphing calculators is preferable over performing computations by hand or by scientific calculators: not only it saves time and efforts, but allows for avoidance of mistakes in performing symbolic computations as well.

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mmeybodi@aut.ac.ir

Systemic Design of Instruction on Achieving the Goals of Undergraduate Level Education in Universities: A Case Study of Makerere University

Alfred Kirigha
Makerere University Kampala
Dr. Neema-Abooki
Makerere University Kampala

Keywords

ADDIE: Analysis, Design, Development, Implementation and Evaluation
FCIT: Faculty of Computing and Information Technologies
ICT: Information Communication Technologies
MANCOVA: Multiple Analysis of Covariance
SOE: School of Education

ABSTRACT

This research focused on the concept of Systems Design to Instruction on achieving the goals of universities at the undergraduate level. The study was occasioned by the slow integration of new methodologies in teaching and learning which focus on teacher centeredness. System Design to Instruction aims to integrate Information Communication Technologies [ICT] into teaching and learning. While the goals of the university are mainly to encourage life long learning, building interactive relationships with the immediate society and provide intelligent knowledge and distributed intelligence technology, the research aimed at the process of teaching and learning. The emphasis was on two sections: The Faculty of Computing and Information Technology and the School of Education. These two form the crux to fully integrating technology with pedagogy in the teaching-learning and research process at Makerere University.

The study was a cross sectional survey based on a total of 225 respondents, consisting of 100 third year students of Bachelor of Arts in Education and 125 third year students of Bachelor of Science in Computer Science. Data was collected mainly through closed ended and open ended questionnaires. The researcher also compared results of set categories of students in the two organs who were exposed to ICT. Raw data was later presented and analysed using descriptive statistics of frequency distribution in nature and Multiple Analysis of Co variance (MANCOVA.). It was observed that the significant dependent variables that affected the Bachelor of Science in Computer Science were: evaluation of student social setting, research in the internet and other related technologies, different learning methods, different forms of instruction in teaching and learning, administering regular exams and reviewing performance according to course objectives. On the other hand at the School of Education the following affected students: Any form of educational technology used, incorporation of modern methods in teaching and learning, evaluation of student social setting in learning and sufficient technological resources for teaching and research.

It was found out that the Systems Design to Instruction which is conceptualised using Analysis, Design, Development, Implementation and Evaluation [ADDIE] is important as it addressed the ever increasing needs of the students by leading to: increased learning, knowledge generation, response to learning problems and efficiency in teaching and learning. Having concluded in a nutshell that ADDIE leads to the attainment of university goals, the researcher recommended that for ADDIE to achieve goals at the undergraduate level there is need to lay emphasis on the learner in this process.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 35–40.
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mmeybodi@aut.ac.ir

INTRODUCTION

In Africa, like elsewhere in the developing world, tertiary education systems continue to be elitist as regards access and the socio-economic composition of the student body. Financial resources have been insufficient to sustain growth of enrolment and improvement of quality [16]. Even though tertiary-level enrolments have grown significantly in virtually all countries in the developing world, the enrolment gap between the most advanced economies and developing countries has widened [14].

In Uganda, tertiary institutions like Makerere University, which has the right of primogeniture, has made a concerted effort of adopting full scale Information Communication Technologies (ICT). The Faculty of Computing and Information Technology in Makerere University enlists the largest increase in student numbers as per the 2006 intake. That the Faculty conducts day and evening classes in order to respond to the growing demand for higher education is a clear signal of the globalisation of education.

Ref. [7] spells out some of the goals which impact the university and therefore the undergraduate level as: learner centeredness, ability to encourage learning, provision of higher education at affordable rates, building interactive collaborative relationships with its immediate society, and distributed-intelligence technology which is crucial in the teaching-learning process.

The integration of technology into learning, research and management is still at its infancy in most universities. The Internet based degree programmes, especially the Masters in Business Administration (MBA) in Business and e-Business mounted by renowned universities in Europe and the USA as well as the Internet based Open Universities could, for instance, constitute challenges to the brick and mortar traditional university education, if the latter does not adequately respond to opportunities offered by ICT (Eric Kluyfhout, 2000).

Ways in which universities have adapted is by improving the methodology and approach in the development of courses. A modern method which has gained prominence in the last 50 years is the Systemic Design to Instruction, developed in the 1950's and 1960's [12].

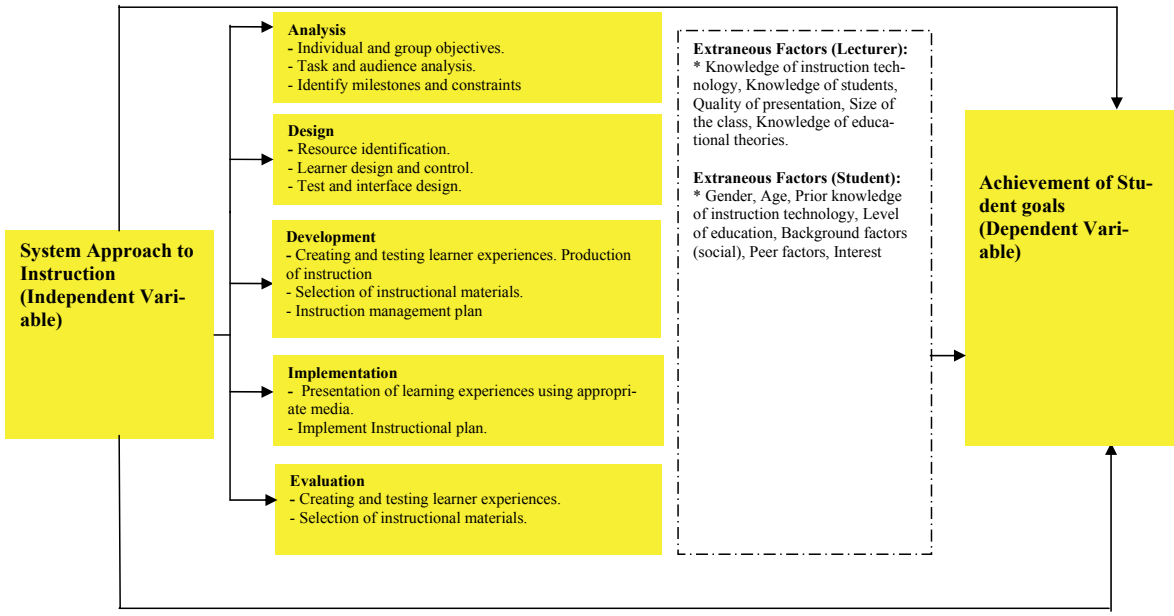
Systems are made up of sub components. A typical system has the Technical sub-system, the supportive, maintenance and adaptive sub-system. Educational institutions are service organizations and can be modelled along these sub-components. The main emphasis of the research is on the technical sub-system which is responsible for converting inputs into outputs. For, the goal of systems in tertiary institutions is to increase the effectiveness and efficiency of the total system (university) via the development of manageable subsystems (teams or groups within the university system) with common focuses or purposes.

In Makerere University the integration of ICT into learning is still at its infancy. The integration of the universities functions was through an appropriate ICT framework; namely the Systemic Approach to Instruction. The approach is one of the primary ways through which education will be delivered in today's universities to ensure efficiency in the education system of the university.

It needs to be elucidated that the systemic approach [see Fig.1) can be grouped into five interconnected phases: Analysis, Design Development, Implementation and Evaluation [ADDIE].

mmeybodi@aut.ac.ir

Figure 1: Standard Systems View of Instructional Systems Design,
Source: Adopted and Modified from [6] & [9]. Systems Design to Instruction.



Analysis is assessing how educational technology affects individual/group efforts and objectives [6]. Design emphasises the identification of the required resources to complete the tasks and implement the chosen solution in analysis. Development is a process of creating and testing learning experiences. The solution is implemented in the fourth phase namely, implementation. Emphasis is on the presentation of learning experiences to the participants using appropriate media for on-campus and distance learning. The last phase is Evaluation with the aim of bridging the gap between student knowledge and the lecturer. It focuses at both formative evaluation and summative [13].

The specific objectives were therefore:

- To find out the effect of analysis on achievement of university goals at the undergraduate level.
- To investigate the effect of design on the achievement of university goals at the undergraduate level.
- To check the influence of development on the achievement of university goals
- To investigate how the implementation of the Systems Approach to Instruction has led to the achievement of university goals.
- To find out how evaluation of the Systems Approach to Instruction affects the achievement of university goals.

Meanwhile, the extraneous factors identified by the study were: knowledge of instruction technology, knowledge of students, quality of presentation, size of class, knowledge of educational theories, range of backgrounds, knowledge, attitudes, skills of students, gender, age, level of education, peer factors and interest.

The investigation therefore, ultimately aimed at delving into how the Analysis, Design, Development, Implementation and Evaluation of instruction were done in order to achieve student goals.

METHODOLOGY

The researcher opted for the quantitative design approach. The category used in this design is the descriptive research. In this type of research the cross sectional survey method was chosen. The reason is that it provided an opportunity to conduct two or more related cross-sectional studies at the same point in time with different groups being sampled by each cross sectional study [1]. This was done both in the Faculty of Computing and Information Technology (FCIT) and in the School of Education (SOE).

When analysing student records, the researcher adopted purposive sampling by selecting third year students in the SOE

mmeybodi@aut.ac.ir

and the same in the FCIT who were well exposed in pedagogy, either through online blackboards or in the teaching and learning process.

FINDINGS AND DISCUSSION

The estimated student sample size in the FCIT was 150 students and SOE 120. The actual respondents within the FCIT turned out to be 125 respondents and the SOE 100 students.

Within the School of Education (SOE), undergraduate level, 100 students gave replies to the questionnaire distributed: 97 (97%) of the students were between the age of 20 to 35 and 3 (3 %) between the age of 36-55; A total of 56 males (56%) and 43 (43%) females responded. Only one student (1%) did not state the gender.

The basic information shows that 31% of SOE students in the third year had no knowledge of ICT technologies, this is notwithstanding the fact that a greater majority were between the ages of 20-35 years.

At the same time at FCIT, a total of 125 third year students responded to the questionnaire. The general view that was inferred is that the undergraduate students who answered the questionnaire were young with a greater majority being male students. At the same time, a larger percentage of SOE students, 15% more than the FCIT, had previous knowledge of ICT.

The ***systemic analysis of instruction*** contained in student questionnaire within the School of Education concedes that: 44% of lecturers rarely demonstrate an understanding of course objectives; 56% agree that lecturers combine manual instruction and educational technology; 51% disagreed that any form of educational technology is used; 51% stated that modern methods have not been incorporated; when asked whether student needs were integrated into instruction 51% gave a no answer; 68% disagreed that the gap between student and lecturer is being bridged; There was little emphasis on evaluation of student social setting with 71 (71%) who agreed to the statement; 61% agreed that there should be more emphasis on online learning.

The students thought that the faculty is not addressing student needs and more could be done to cover the gaps between lecturer and student. In addition extra attention to online learning is required.

At the FCIT the response was: 60% agreed that some do show an understanding of course objectives. 72% agreed that lecturers combine manual instruction and information communication technologies. 85.6% concurred that a least one form of educational technology was used; Incorporation of modern methods in learning received a positive response of 76%. There was also focus on Integration of student needs into instruction 59.2%. Discovery of student and lecturer gaps received a 59.2% disaffirmation; Student social setting was addressed with a 72.8% positive response. 64% agreed that there is still more that can be done using online learning.

The most apparent replies for ***systemic design of instruction*** within the SOE and FCIT were: There were hardly any sufficient technological resources to facilitate teaching and research within the SOE and FCIT with scores of 79% and 68.8% respectively. A gap was noted in aligning lesson design with student needs in the SOE and the FCIT. Students also felt that lecturers required students to research with affirmative replies of 82.4% within the FCIT 64% within the SOE. FCIT students (52.8%) agreed that lesson design matched university needs while only 44% gave the same response in the SOE. The lesson design was better in the FCIT than in the SOE. Lastly the tests designed at FCIT and SOE did not adequately address the different domains.

Systemic development of instruction had two questions. 84% and 82.4% in the SOE and FCIT affirmed that different learning methods were used. The reply to the first question whether students use technology that facilitates distance learning gave contradictory responses in the SOE (73%) and a positive reply of 38% in the FCIT. Both concurred that students are involved in the teaching and learning process with 80.0% response in the SOE and 81.6% in the FCIT giving the same answer.

Therefore, the FCIT had taken appropriate steps to facilitate distance learning while in the SOE distance learning was hardly used. It was commendable that at the SOE and FCIT students were involved in the teaching and learning process. The SOE should try to advocate techniques that encourage distance learning for instance online blackboards.

Systemic evaluation of instruction was composed of three questions. The response to the query whether they were given regular exams saw below average percent response of a 'yes' answer of 41 (41.0%) in the SOE and a fair response of 67 (53.6%) at the FCIT. It was plain that performance was being reviewed with course objectives with 64 (64.0%) in the SOE and 78 (62.4%) being in agreement that surely the university does this. The enquiry about whether exams are given online saw a gainsay response with 85 (68.0%) agreeing in the FCIT and 86 (86.0%) giving a negative answer. This means that in the SOE, it heavily relies on giving exams online.

ADDIE leading to learning gave a positive response of 77 (77.0%) in the SOE, 93 (74.4%) in the FCIT which means that ADDIE facilitates learning; ADDIE leads to knowledge generation had in no doubt answer of 83 (83.0%) in SOE and 97 (77.6%) in FCIT and therefore can be deduced that ADDIE is important in research; ADDIE leading to student learning gave a response of 90 (90.0%) in SOE and 105 (84.0%) in the FCIT and therefore the conclusion was that it was important for the cognitive and psychomotor domains; Whether ADDIE responds to learning problems?

It was worthwhile to conclude that from a quick look ADDIE seems to lead to increased learning, knowledge generation, student learning responds to learning problems and student needs were addressed through its use. This applied to both the SOE and FCIT.

mmeybodi@aut.ac.ir

Multivariate Analysis Results

The significance level chosen to enable multivariate analysis was p = 0.05. The Dependent Variables gave a significant relationship with ADDIE because the significance level is less than 0.05. ADDIE leads to increased learning gives p (0.000), ADDIE helps in knowledge generation p (0.003), ADDIE leads to greater student learning p (0.000), response of ADDIE to student problems p (0.000) and ADDIE addressing the ever increasing student needs of p (0.005). This means that the independent variable under Analysis, Design, Development, Implementation and Evaluation were significant in explaining the achievement of university goals within the context of FCIT.

The fixed factors or extraneous variables that affected the Dependent Variable were: Gender p (0.029), previous knowledge of ICT p (0.000) and the co-effect of the two. This means that gender and previous knowledge in ICT are important extraneous factors to consider within the context of the FCIT and therefore the researcher subscribes that such factors have an effect on achievement of university goals.

The Dependent Variable in the SOE that showed a significant effect was "ADDIE helps in knowledge generation" with p [0.036]. The reason why this might be the only factor identified might be explained by the effect of between-subjects [i.e. variability between respondent to respondent or experimental error [2]].

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

RQ1. What is the effect of analysis of instruction on the achievement of university goals for undergraduate level?

The response to this question received these noteworthy significant responses: That within our own context the implementation of modern methods of learning both in the SOE and FCIT was still lagging behind, more than, (50%) agreed that Makerere University still used archaic methods in teaching-learning and research. This was in agreement to conclusions reached by Ref. [10], which identified little attention being paid to the analysis of the needs in conformance with the environment and existing situation.

The undergraduate respondents in the SOE and FCIT said that the Faculty does not try to discover the gaps between lecturer and student. This was in line with Ref. [5], who stated that before designing instruction, front-end analysis should be undertaken to match student, lecturer and university goals. The researcher concurs with Ref. [5] on the need to conduct a thorough front-end analysis to ensure that no disparity exists between students and lecturers at the undergraduate level.

An understanding of course objectives and incorporation of different learning methods was identified as a crucial factor in Analysis in the SOE and FCIT. Students in the FCIT gave a more positive response of 60%. This is in line with [4], who stated that an understanding of the context is a pragmatic and crucial aspect of analysis. The final significant factor in Analysis that was identified as crucial was the analysis of student social setting. This was particularly so in the SOE where, 71.7% stated that there was an analysis of student social setting, a crucial factor in responding to learning needs [8]. The researcher therefore, after examining these facts, concluded that there is an effect of analysis of instruction on the achievement of goals for the undergraduate level.

RQ2. What is the effect of design of instruction on the achievement of university goals for undergraduate level?

Design was addressed by an eight-fold-question for both lecturers and students. The significant responses received under this indicated the following: There was need to have a lesson design in tune with university needs, (55%) of the students in the SOE stated that the lesson design was not in line with university needs. Lecturers and students assented to the fact that the resources available were elfin compared to university needs.

At the School of Education almost, (53%) indicated that the lesson design was in accord with university needs. This means that there was a palpable relationship between design of instruction and the achievement of university goals. The research showed that the Dependent Variable that had an explicit relationship with design of instruction is response to learning problems and increased learning.

The foregoing ultimately meant that design factors which had an impact on university goals were: lesson designs in line with student, user and university needs; sufficiency of technological resources, need for research in the internet.

RQ3. What is the effect of development of instruction on the achievement of university goals?

This stage got many significant responses from the FCIT compared to SOE. Those who indicated that indeed different forms of instruction were being used were only, (29.6%) while those who said negated the status quo were, (61.6%).

The second factor that influenced development of instruction was different learning methods. This received a response of, (82.4%) in the FCIT. According to these respondents, different learning methods were being adopted. This is more in consonance with [9] who propagated for the importance of adopting a learning strategy when adopting the framework.

RQ4. What is the effect of implementation of instruction on the achievement of university goals?

The main significant factor under implementation was the need to involve the student in the teaching and learning process. The School of Education reported the most significant contribution to this. This was in harmony with conclusions drawn by Ref. [13] that the implemented design should be more learner centred. The qualitative responses from the open ended questionnaires tend to favour conclusions drawn by Ref. [3] which showed that the reason why some people chose to implement some form of electronic learning was because it provided alternative forms of learning with the opinion that ICT would enable the instructor to achieve learner goals leading to

mmeybodi@aut.ac.ir

increased learning; which is one of the objectives which Makerere asserts.

RQ5. Is there an effect on evaluation of instruction on the achievement of university goals?

The evaluation in the due regard entailed both formative and summative aspects. It was noted that the Dependent Variable, significantly influenced by evaluation, was the response to learning problems. A higher 'no' score of 50% compared to 41% 'yes' score in the SOE indicated that evaluation does not respond to learning problems. Most students agreed that the exams were given regularly an issue that the research concurs with the study done by Ref. [15] that revealed designers usually conduct their evaluations earlier in the process and thus focussed on the formative aspect.

The researcher also identified other extraneous variables that, in addition to the aforementioned had an effect on the respondents. These factors were:

Age which had an effect on: understanding of course objectives, form of educational technology used.

Gender that had an effect on: whether or not students research in the internet, incorporation of modern methods of learning.

To draw recommendations one has to look from within and without in order to discover how to improve. To achieve this it is imperative that:

i) In order to ensure effective analysis of instruction there is need to carry out an analysis of student needs and match these with university needs. This has to be done at certain intervals and using clear benchmarks.

ii) It is important to bridge the gap between students and lecturers at undergraduate levels when designing instruction.

iii) There is need to involve students in the implementation of instruction by having clear objectives, well defined needs and objectives.

iv) Universities should emphasise formative evaluation when developing instruction and also employ summative evaluation at fixed stages in the undergraduate level.

In a nutshell, it was crucial to involve the students in all the stages in the Systemic Design to Instruction in order to ensure that there is no sub-optimisation of goals of curriculum designers. In addition, student involvement ensures that the final customer, [i.e. the student] is contented and therefore an effective learning environment is fostered. Therefore, it is imperative that to improve instruction the Analysis, Design, Development, Implementation and Evaluation of instruction be done with meticulous care focussing on the above issues pointed out.

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mmeybodi@aut.ac.ir

A Systems Model for Authentic Pedagogy:

Conceptualizing a Scaleable, University-wide Production Curriculum

Ames T. Brown III
School of Education & Human Resources
University of Bridgeport
Bridgeport, CT 06604
ames@bridgeport.edu

***Abstract* – A systems curriculum model of authentic pedagogy for universities is proposed which expands the "big picture" of selected courses to the level of an articulated system. This authentic system simultaneously articulates a selection of multiple courses across multiple academic departments and multiple semesters to a common goal: the authentic production of a digital technology product.**

***Keywords:* authentic pedagogy, authentic learning, project based learning, curriculum design, technology education, engineering education, higher education reform**

I. Introduction

Today, digital technology products require enormously complex social interactions to reach market. The degree of attainment in navigating this social complexity is often the determining factor in their success, not their technical merits. Those products which survive the process are often marred by hilariously obvious 'social' defects. In our increasingly technology-mediated lives, we've all been affected by the 'uneducated' social processes of technology production.

The Apple/AT&T iPhone is a recent example. The first month's billing cycle after the launch of the product on June 29, 2007 used a process where "some users reported bills up to 300 pages long, printed on both sides, itemizing every system transmission of data—even those data transfers hidden to the user" [1]. The 'viral video' posted by Justine Ezarik [2], a graphic designer from Pittsburgh, viscerally documented the physical scale of the bill, precipitating international news network coverage of the issue. In two months a new, leaner billing system was announced.

At the same time AT&T was being grilled by the media on the billing process for the new 'smart' phone, Apple was excoriated for not providing a SDK (software development kit) for developers to create software for the iPhone, critical for any 'smart' PDA-type phone device. On October 17, 2007 Apple reported that it would be releasing an iPhone SDK in February 2008 [3].

The Apple iPhone was launched with the characteristics of a 'bleeding edge' device using a 'cutting edge' ad campaign, i.e. the market expectations had more room for 'forgiveness' than typical product launches. Most technology devices competing as new models serving established markets would have 'died' when plagued with such widely documented issues. Few digital technology appliances can survive a half-year period of patches to major problems. Why do such situations occur in today's cycles of technology development?

Digital technology development today requires coordination between many teams cutting across an array of knowledge domains. In higher education these teams correlate to academic disciplines and academic departments. However, the way typical university programs are configured, 'majors' in the different disciplines that impact digital technology development in the 'real world' are rarely offered the *authentic* experience of collaborating and integrating their knowledge sets. This results in inexperienced and often 'infantile' collaboration behavior once graduates enter the workforce.

Senge calls the ability to integrate knowledge sets *collective intelligence*, a characteristic of "learning organizations" where people engage in "integrated dialogue" across large system barriers using a contextualized "new language" to achieve "alignment" and "commonality of purpose" [4]. Higher education institutions can help prepare students for the complexities of 21st Century digital technology advancement by offering opportunities for Business majors, Communications majors, Computer Science majors, Design majors, Education majors, Engineering majors, English majors, etc. to learn how to bridge their knowledge sets.

The model of authentic pedagogy developed in this paper seeks to remedy this gap by elevating selected university courses to the level of an articulated system. Students are afforded the opportunity to take one or more courses during their studies which are simultaneously linked with other courses across multiple academic departments, i.e. a set of courses where students are collectively learning and working together.

Fig. 1 shows a sample curriculum system which integrates a total of eighteen courses. The articulated system consists of six courses offered by six academic units or departments each semester across three semesters (one academic year). These articulated courses maximize *collective intelligence*, behaving as a real-world learning organization with a common goal: *the collective design, production, and marketing of an* ***authentic*** *technology product*.

ACADEMIC UNIT	FALL	SPRING	SUMMER
Advertising			
Business and Finance			
Computer Science			
Electrical Engineering			
Graphic Design			
Human Resources Management			
Industrial Design			
Instructional Technology			
Technical Writing			

Fig. 1: Sample system articulating 3 semesters/18 courses.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 41–46.
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II. Developing an Authentic Systems Model

Authentic pedagogy is associated with a family of pedagogic theories called "constructivism." It prioritizes learning through cognitive processes tied directly to the same processes used by authentic practitioners of particular knowledge domains. A combined web search on the phrases "authentic learning" and "authentic pedagogy" usually yields more than two hundred thousand sites [5]. A majority of these sites consider issues related to childhood and adolescent education (grade school). For instance, an initiative in the United States uses "working on the work" (WOW) as the focus for curriculum design:

> Authentically engaged students see meaning in what they are doing, and that meaning is connected to ends or results that truly matter to the students. Indeed, these authentically engaged students may be willing to do some boring and otherwise meaningless tasks, precisely because they see the linkage between what is being done and some task-related end of significant consequence to them [6].

Although higher education is still largely driven by lecture/lab-based, didactic pedagogies, there is a growing trend towards more constructivist approaches. In the United States, the National Center of Excellence for Advanced Manufacturing Education (NCME) believes "a central learning pattern that anchors each learning activity to real world applications" must meet two criteria:

1) *The Big Picture:* The big picture is the framework for learning. Before specific theories and skills are tackled, instructors construct a framework by defining the value these theories and skills have and the ways in which they might be used on a day-to-day basis.
2) *Context:* Context is the foundation for application. In order to mesh theory with practice, specific settings are described or replicated in the classroom, so that learning tasks can be pursued with an understanding of why and how specific tasks are performed in the real world. [7]

The Dutch IVLOS Institute identifies four test questions to consider when viewing or designing different problem cases for authentic curriculum:

1) *How authentic is the case?* To which extent does the case resemble cases from students' future professional academic practices? To which extent is the case in touch with students' experiences and daily lives?
2) *How complex and open is the task?* Are there many issues and uncertainties involved in the problem? Is there a known, unique solution to the problem or are there various alternative solutions to be considered?
3) *How well-structured is the case?* Are there useful concepts, theories and methods available to support finding solutions? Are there any hidden aspects of the problem?
4) *Is the case challenging?* Do the students consider the problem genuine and worth finding a solution? Can the problem be solved within the available time? [8]

When considering individual university courses, these criteria and questions work well for evaluating the authentic nature of problem cases tied to the global technology industry in academic departments as diverse as Business, Communications, Computer Science, Education, Engineering, English, and Graphic Design. Answering them well means our Model has to identify a real-world technology product for production by the students. This scope and complexity is far beyond what can be designed into the curriculum of any one department or course. As with the authentic world of digital technology, courses need to pedagogically address Senge's concept of "collective intelligence."

Therefore, we need to ask another question: *Does the task require the use of "collective intelligence" to complete it?*



Fig. 2: IBM MetaPad prototype versus UMPC market devices [9].

Consider the various enterprise-level departmental areas which are involved in the design, production, and marketing of an MP3 player, PDA, notebook computer, or any of a variety of other fairly ubiquitous technology devices. Also consider the small internal collaboration resulting in the IBM MetaPad prototype in 2002 versus the more complex collaborations required to turn such research concepts into marketable ultra mobile devices by 2006 (see Fig. 2). Universities can authentically entice students during such pre-market time spans. Through inter-departmental curricular collaboration, students can work to produce devices for sale in their own university's internal micromarket well before similar devices become available to the average consumer.

Building on the NCME and IVLOS concepts of *authentic pedagogy*, along with Senge's concept of *collective intelligence*, we can synchronize academic time with real-world economic time. The resulting model is fairly easy to map for an authentic curriculum cycle. Some academic units might have a two or three semester course sequence, whereas others might only have a single semester course tied into the articulated curriculum system (also see table in Fig. 1):

- *Fall semester*: Design cycle articulated curriculum where student teams establish working patterns between disciplines leading to prototype designs for a technology platform device and/or technology accessory devices.
- *Spring semester*: Production cycle articulated curriculum where student teams collaborate between disciplines on selecting prototype candidates, testing, refining, finalizing, documenting, and announcing the new product line.
- *Summer semester*: Marketing cycle articulated curriculum where student teams collaborate between disciplines on promotion, sales, manufacturing, support, and the rate of return for funding next year's design cycle.

mmeybodi@aut.ac.ir

III. Identifying an Authentic Product

An authentic technology product requires an authentic consumer market. In American universities today it is generally assumed that students will have their own computers. Many universities have also instituted laptop requirements either at the university level or for selected majors. Tapping this market within the university's own population offers many possibilities as an authentic outlet for the production of an authentic technology product or product-line on an annual academic cycle.

The recent development of the "ultra mobile computer" paradigm illustrated in Fig. 2 provides an interesting product exemplar for the Authentic Curriculum System Model. In 2002 IBM demonstrated its proof of concept for ultra mobile computing by placing the logic board and hard disk into a small form factor which could then be snapped into a variety of shells containing the larger interface elements such as screen, keyboard, optical drive, etc. Microsoft's development of the "origami" reference platform for the Ultra-Mobile PC (UMPC) computing form factor emerged in March 2006 [10] and a few early-market devices arriving by the end of the year. In June 2007, ASUSTeK announced a 'barebones' UMPC for $200 which eventually reached the market at $300 in October 2007 [11].

Here we see a six-year window from 'bleeding-edge' research prototype to inexpensive market production, i.e. 1½ undergraduate or doctoral degree cycles or 2–3 masters degree cycles. A university can harness an Authentic Curriculum System Model to inspire students to move much more quickly from technology learning/research to technology product/use. The authentic motivation of having something which is unique and useful, that you as a student (and faculty member) have been involved in producing, can create an authentic market force within the university.

Tying a student-produced technology platform to the mission and goals of the university enables opportunities for truly systemic curriculum integration. The development of an Authentic Curriculum System Model resulting in a student-produced 'product-line' each academic year might begin on a small-scale with a line of unique accessory devices. Considering the UMPC exemplar, eventually the Model could expand to include both a unique cutting-edge platform and unique accessory devices.

Most of the academic resources harnessed by this Model are already present, distributed across the various academic units or departments within a university. Two necessary technology resources which might not be present are depicted in Fig. 3 (a 3D printing system in the Industrial Design academic program and a turnkey printed circuit board (PCB) production system in the Electrical Engineering academic program). A $100,000 start-up expenditure for these resources is a relatively small cost within university budgets. Initial university culture 'buy-in' combined with a successful pilot of such an Authentic Curriculum Model would most likely lead to much larger resource investments as the curriculum system scales to support more classes, students, academic units or departments, and faculty.



Fig. 3: A 3D printing system and a PCB production system [12].

The ability to produce ready-to-use form factor prototype shells and logic board prototypes in-house by the end of the fall semester (design cycle) allows multiple prototype designs to be considered, consolidated, refined, and finalized during the spring semester (production cycle) and then manufactured and marketed internally to the university community during the summer semester (marketing cycle).

In 2008, a new company will be marketing a component system for buyers to design their own technology devices. Illustrated in Fig. 4, the product provides buyers with a selection of generic component circuits in snap-together form-factor modules and a software development kit (SDK) to design custom software for the custom devices:

> As teenagers, personal computers were still new and as much a challenge to tinker with as they were to operate. With BUG, we want people to recapture and share this excitement again, and we want them to apply this to their everyday device. We believe everybody is an inventor at heart, so we've developed a platform for users to create and forever modify their favorite gadget, allowing for ultimate customization and use [13].

This example illustrates viability and hints at sophisticated possibilities for our Authentic Curriculum System Model.

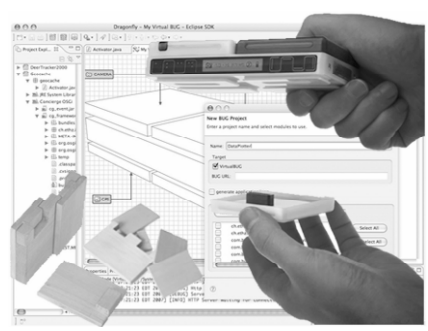


Fig. 4: Customizable device kit by Bug Labs.

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IV. Synchronizing the Curriculum System

Let us consider what such an Authentic Curriculum System Model might look like which functions on an interdepartmental university level. First, it needs a name and acronym, two common characteristics of such interdisciplinary efforts in universities. A popular initiative is "writing across the curriculum (WAC)," a cross-departmental curriculum theme which has been around in universities for the past thirty years. In the United States, "Quinnipiac University's WAC program currently encompasses 12 schools" with plans to expand it to the "remaining schools and programs" [14].

In our case we will call the initiative *Authentic Technology Across the Curriculum* (ATAC). A university could set its strategic sight on the goal of eventually integrating selected courses in every major academic unit into an ATAC system, much like Quinnipiac's goal for WAC courses. It is important to note that ATAC is an integrated *curriculum system*, whereas WAC is an integrated *curriculum theme*. Whereas WAC requires a limited degree of collaboration among faculty across academic units, ATAC requires intense collaboration among both faculty and students across academic units.

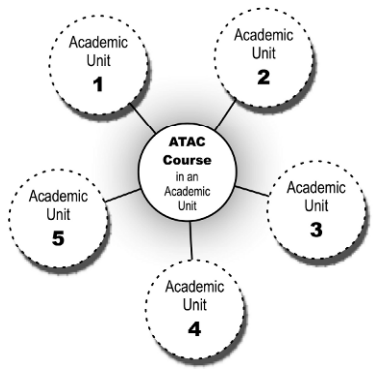


Fig. 5: A small ATAC system with six courses each semester.

For the sake of illustrating the synchronization of an ATAC system, let us consider a small model where six courses in six different academic units or departments are articulated each semester. As shown in Fig. 5, each of these courses has to 'center' itself as part of a *macro-interdepartmental-course* composed of six courses.

Each semester, both the faculty and students in these courses have to think of the collaborative curriculum and project-based-learning between each of the six courses as an articulated whole. In addition, the faculty and students must consider what stage of the ATAC cycle they are collaborating on: beginning, middle, or end. Figs. 6–8 illustrate a small ATAC system across a full academic year cycle [15]. In Fig. 6 articulated courses during Fall (beginning cycle of three in an academic year) place a strong, founding emphasis on collective intelligence and the framing of interdepartmental collaboration processes between courses.

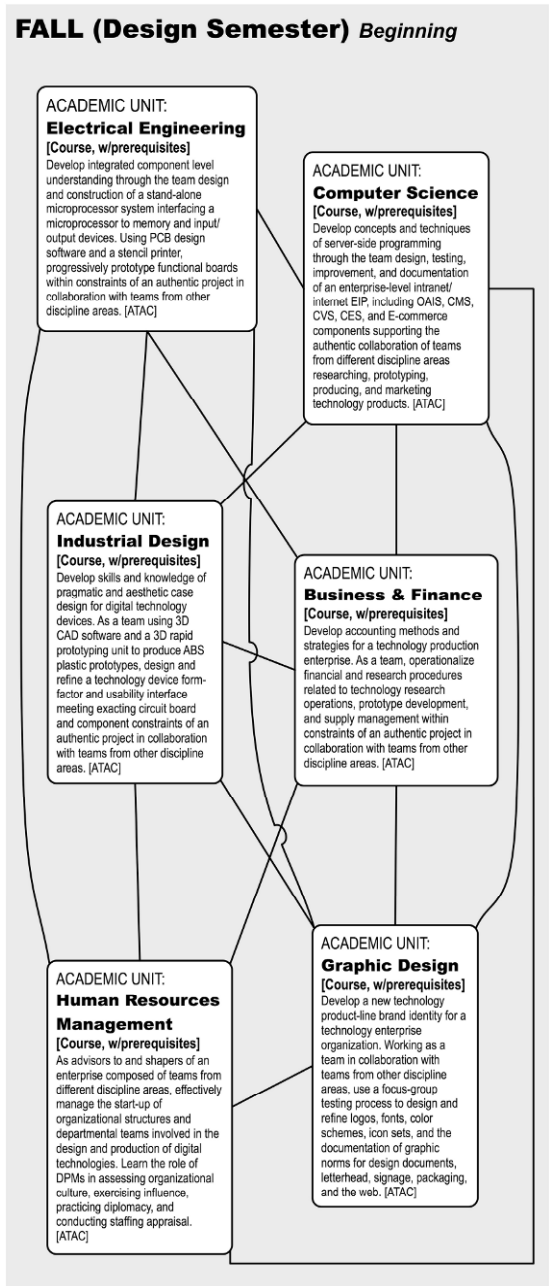


Fig. 6: The Fall Semester (design mode) of a small ATAC system.

During the first two weeks faculty would guide the formation of authentic foci and project teams in each class. The third week might focus on establishing the collective inter-class/team relationships across all the involved classes. Authentically learning about staffing issues, the Human Resources class might play a key role in documenting and matching teams and their collaborative arrangements.

mmeybodi@aut.ac.ir

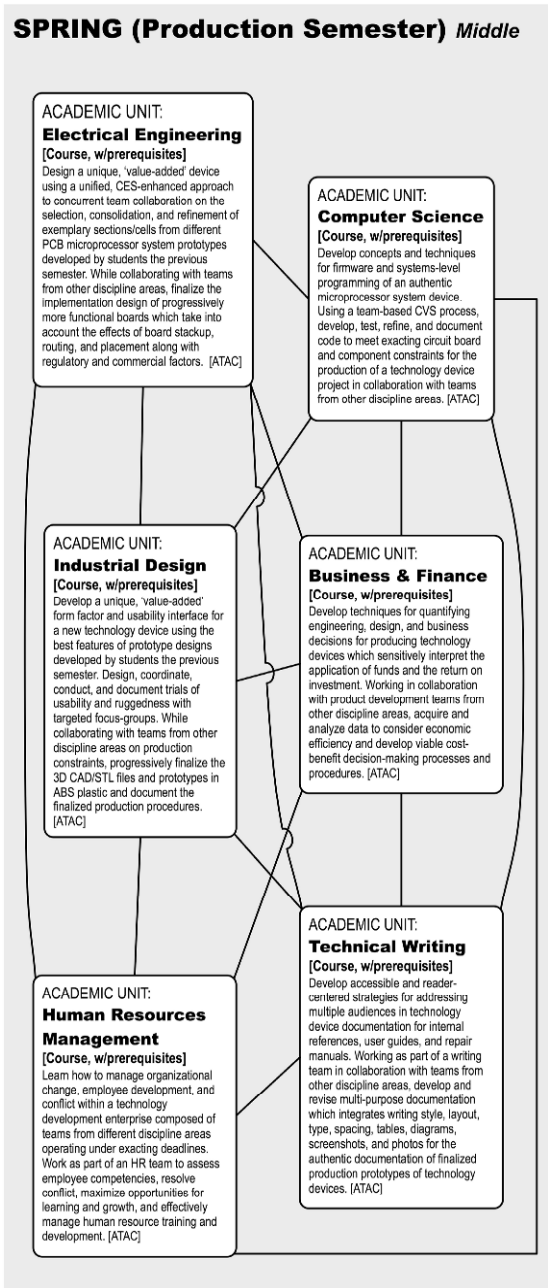


Fig. 7: The Spring (production mode) of a small ATAC system.

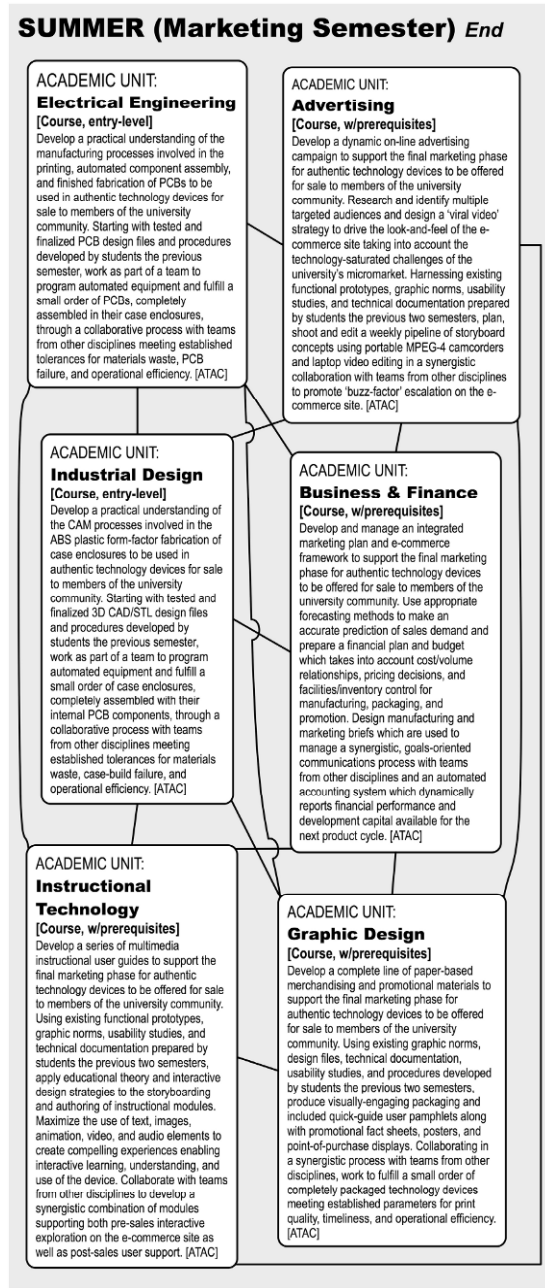


Fig. 8: The Summer (marketing mode) of a small ATAC system.

In Fig. 7 articulated courses during Spring (middle cycle of three in an academic year) address organizational change and transition. The best features of competing device prototypes from the Fall cycle are evaluated, prioritized, and consolidated into a product-line concept. The third week might initiate inter-departmental team unification with a semester focus on finalizing the product-line.

In Fig. 8 articulated courses during Summer (ending cycle for the academic year) concentrate on manufacturing and marketing the product-line of technology devices developed during the Fall and Spring cycles. Entry-level courses in Engineering and Industrial Design devoted to manufacturing create curricular scaffolding for students to envision their possible accomplishments in upper-level ATAC courses.

mmeybodi@aut.ac.ir

Compared to a WAC university program, an ATAC initiative requires a higher degree of planning among faculty and academic units, i.e. a systems approach. Most WAC initiatives have one part-time administrator who also teaches. An ATAC initiative would probably require two part-time administrators who also teach—a co-directorship. Two knowledge sets, usually not present in any one faculty member, are required to coordinate the articulation of an ATAC program:

- *ATAC Curriculum Director*: This faculty member from an education discipline would have the background in interdisciplinary curriculum design and curricular change necessary to help lead faculty in the process of developing course syllabi and cooperative learning techniques to maximize connections between academic units.
- *ATAC Technology Director*: This faculty member from a technology discipline would have the background in corporate technology production and organization necessary to help lead the faculty in the integration of classroom processes as a collective framework matching the authentic operation of a corporate technology enterprise.

The initiation of an ATAC program would also require the repurposing of a large enough space in a university building to allow collaboration between students and faculty. One possibility might be an underutilized suite of study rooms surrounding a reading area in a university library. The reading area could be converted into an exhibit area for technology prototypes and printouts from project teams. The study rooms could become scheduled conference rooms for team meetings.

Figs. 6–8 illustrate a sample ATAC academic year using an eighteen course system (six courses each semester) participated in by nine academic units/departments. However, an ATAC initiative is scalable and could flex to handle a different combination and number of courses each academic year, depending on the shifting priorities of academic programs within the university.

V. Conclusion

Systems integration and responsiveness in technology production organizations is not a simple matter. Information-age enterprises are extremely complex. Although such enterprises lead to tangible products and profit, the work by most of the members of these organizations is virtual, i.e. minds interacting with computers and other minds in highly specialized subcultures. Senge's vision of the "learning organization" as a responsive system reaching the stage of "collective intelligence" is an elusive goal sought by many technology enterprises.

Configuring selected courses in different academic departments across the University as an enterprise-level operation, with a real mission and production cycle, is the ultimate model of authentic pedagogy. Such an initiative requires a group of faculty from specialized subcultures to become a learning organization. Coming together as interested faculty from different university academic units to envision the possibilities of such a curriculum system is the first authentic step.

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[9] This figure is a composite image using technology product images from the following corporate websites: *IBM* http://domino.research.ibm.com/comm/pr.nsf/pages/news.20020206_metapad.html; *Fourier* http://fourier-sys.com/product_data_nova.html; *DualCor* http://dualcor.com/photos.php; and *Samsung* http://product.samsung.com/q1microsite

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[12] The equipment and prices illustrated in this composite image are drawn from the following corporate websites: *Stratasys* http://www.dimensionprinting.com/printers/printing-productspecs1200series.shtml; and *Manncorp* http://www.manncorp.com/turnkey-pro_line

[13] This quote, as well as the images used for the composite in Fig. 4, are drawn from the Bug Labs company website: http://www.buglabs.net

[14] Quinnipiac University, Writing Across the Curriculum, *About WAC*, Quinnipiac, CT, Fall 2006, first paragraph. http://www.quinnipiac.edu/x1052.xml

[15] The course archetypes presented in Figs. 6–8 are similar to course concepts offered in various academic units of many American universities. Each course archetype has been modified to emphasize the *collective intelligence* standard and inter-academic-unit curriculum articulation.

mmeybodi@aut.ac.ir

Evaluating the Usability of the Mobile Interface of an Educational Website

Prof. F. Javier Diaz
B.S. Ivana Harari
B.S. Paola Amadeo
Faculty of Computer Science, National University of La Plata.
La Plata, 1900, ARGENTINA
[javierd, iharari, pamadeo] @info.unlp.edu.ar

Abstract - **This article presents the experience of an evaluation of usability on the first version of the mobile website of the National University of La Plata, Buenos Aires, Argentina. We will present the main characteristics of the traditional website, providing data representative of the amount of information it handles, the sample of participants and their profiles, the characteristics of the test, its organization, the design of spreadsheets used and the diagram of tasks the participants completed during the course of the evaluation.**

It is worth mentioning that the evaluation of this prototype constitutes the starting point for the execution of subsequent stages of redesign and reimplementation, within a methodological framework of adequate reengineering and prototyping.
Testing prototypes of the mobile interface, working with samples on different user profiles, in different contexts and in different cell phone models, will result in the delivery of a product whose quality of use has already been tested and consolidated.

1. Introduction

Mobile technologies have become very popular in Argentina, especially regarding the use of cell phones. It is considered that in our country, the number of active mobile phones in April of this year had reached 37 million, 35.5% more than the same month of last year. [1]
This ongoing tendency in the youth population and even in low-income citizens makes it necessary to have educational websites which allow access from wireless devices. Such is the case of Indiana University [2], the University of Baltimore [3] and Cornell University [4], all located in the United States. In Europe, The Wireless University Forum [5] encompasses all the European universities interested in the development of software and wireless technology.
For this reason we began working in a project to provide mobile access to the website of the National University of La Plata [6], by means of the realization of an adequate user interface for mobile phones. The website of the UNLP is second in position in the national ranking of universities on the Internet, after the website of the University of Buenos Aires and before the Universidad Tecnológica Nacional and the University of Córdoba. It is also 22nd in the Latin American ranking, led by the National University of San Pablo. The ranking was elaborated by the Spanish National Research Council (Consejo Superior de Investigaciones Científicas de España, CSIC), according to their own cybermetric indicators [7].
The National University of La Plata has over 90 thousand students, 10 thousand teachers and over 40 thousand graduates. It is constituted by a university system comprising 17 faculties, 5 pre-university schools and 9 museums, with over 100 degree courses and over 100 postgraduate courses. All are dependencies which are scattered geographically in different sectors of the city [8].
According to the Google search engine, there are around 292.000 web pages under the domain unlp.edu.ar. These data illustrate the immensurable amount of information the website handles, as well as its level of heterogeneity and dispersion. They also indicate the many different user profiles which access the site, with different queries, interests and tasks in mind.
The completion of the mobile website of the UNLP will allow our university community, administration staff, students, teachers, non-teaching staff, potential students and other visitors to access essential information regarding the University, using their mobile phones with access to the Internet.
All this complexity implies a great design challenge, as the version of the website must be more reduced, as required in mobile interfaces, with a more restricted content, more succinct information, with a simpler browsing, due to the great limitations of the screen.

II. General characteristics of the website of the UNLP

The National University of La Plata is constituted by a university system comprising 17 faculties, 5 pre-university schools 9 museums and 16 secretaries. Most of these dependencies have and administer their own web sites, reason for which, although these can be accessed through the site of the UNLP, this site has problems regarding the decentralization of the information, opening of new browser windows resulting in a loss of control over the user, difficulty of having a common search system, among others. This is what the site of the University looks like:

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 47–52.
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Fig.1. UNLP homepage traditional site

- Sector A: Main menu. Most important access of the site.
- Sector B: Additional content.
- Sector C: Search, shortcuts.
- Sector D: Hyperlinks to external sites.
- Sector E: News.

Analysis of the use of the website

The usage statistics show a steady increase in visits since the launch of the website in May 2005. This can be observed in the following chart of the average of daily visits per month:

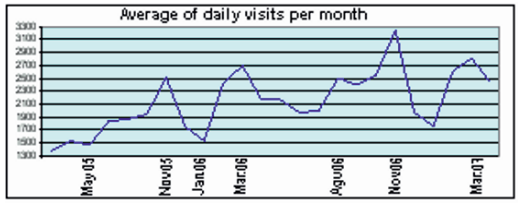


Fig.2. Average of visits per month

There is a clear increase in the visits in the months of March and November, which correspond to the start and end of the academic year, including the period of registration and enrollment in the courses.

The site has been analyzed according to the different ways of access, and it has been noted that, because of the permanent incorporation of contents to the website, there is a constant evolution in the access through search engines.

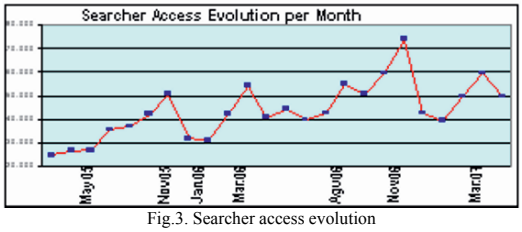


Fig.3. Searcher access evolution

Regarding the most visited pages, which is fundamental information for the design stage, specifically for the selection of contents for the mobile interface, the results are as follows:

TABLE I
MOST VISITED PAGES

Subjects	Visits
Syllabuses	362.195
News	237.721
Courses of studies	208.503
Authorities	154.964
Contests	71.869
Strategic Plan	69.097
Drawings of entrance to the schools	42.628
Postgraduate courses	30.877
Human Rights	19.021
Subscriptions Forms	18.480

It is important to emphasize the high degree of interaction with the users. Since the launch of the website there have been 14 polls which have been taken 43.000 times. There have also been 7200 e-mails and 75.000 subscriptions and queries on different specific services, such as contests, enrollment in courses, etch.

III. CHARACTERISTICS OF THE MOBILE WEBSITE

Towards the end of 2006, we proposed the development of the mobile website for the UNLP, which would be created by the Web development team of the Rectory of the University together with the Department of User-Centered Design of the Faculty of Computer Science.

We then planned a schedule of activities corresponding to a re-engineering process to suit the mobile version of the website.

TABLE 1I
SCHEDULE OF ACTIVITIES

Phase	Length	State
Pre-design	3 months	Finished
Design	2 months	Finished
Development of the Prototype	3 months	Finished
Heuristic Evaluation	1 month	Finished
Usability Tests	1 month	Finished
Re-design	1 month	Begun
Production	1 month	

Pre-design

The portal was analyzed from different perspectives -most significant content, most visited pages, periods of most visits, most requested information, most popular searches, among others.

We also focused on the development of mobile interfaces for educational websites, investigating mobile-specific design,

mmeybodi@aut.ac.ir

examples on the market, trends in the most common information and contents visualized in the mobile interface. During this phase, we analyzed the diversification of mobile phones on the market and their incidence in the design of the mobile interface. We also studied development alternatives for the website, as well as appropriate mechanisms to automatically support both its fixed and mobile Internet form.

Design
We worked on the content of the website, selecting, filtering and dismissing information. The content and the browsing structure were reorganized, focusing on interaction objects appropriate for mobile phones. The following section introduces the most important matters in relation to design.

Development of the prototype
At this stage we developed a high level prototype in order to perform an evaluation on end users. It is an evolutionary prototype, which means any necessary modifications will be introduced to the prototype itself, developing into the final product.

Development of the heuristic evaluation
The designers of the website verified the compliance of the prototype to W3C norms for mobile websites [9].
Each one of the suggestions was considered for correcting the prototype in any necessary aspect.

Usability Tests
We organized a usability test for the mobile interface on 30 individuals with different backgrounds in the use of cell phones and the website of the university in its fixed form. This stage is going to be described throughout the article.

Re-design
In this phase the prototype will be improved, solving the problems detected during the usability test. Hence, the mobile website will be launched with all assessments and usability tests completed.

Production stage
It is estimated that by the end of the current year the website will be accessible via mobile phone to the general public.

IV. Design aspects

The design of the mobile website consisted of a series activities contemplated in the design recommendations for this type of interface. This article will present a summary of these activities, together with the most important screen captions, describing the navigation system and the most relevant visualization aspects. The design process in its entirety can be found in the reference. [10]
During the development stage, we used mainly the simulator OpenWave SDK 6.2.2 [11] Physical cell hones were used for the usability test.

Applying design considerations regarding the content (filtering, dismissal and reorganization), browsing (by content, forward and backward, relocation of hyperlinks at the end of each page), mechanisms of interaction (minimizing the entrance of data, providing shortcuts, searches, hierarchical menus, radio buttons, lists), vertical scrolling and queries, the resulting main page is as follows:



Fig. 4. Prototype

The hyperlinks located in section A of the traditional web site were located as hyperlinks in the main page, together with the most popular hyperlinks of the other sections, as indicated by the statistics of visits to the web site.
With the aim of providing shortcuts to facilitate browsing, each option was assigned a number. In this way, in order to access a section, the user can press the number, select it with the navigation buttons of the cell phone or with a stylus, depending on the device.
The heading of each page includes contextual information about the current section, the hyperlinks visited to get there and an icon to return to the main page.

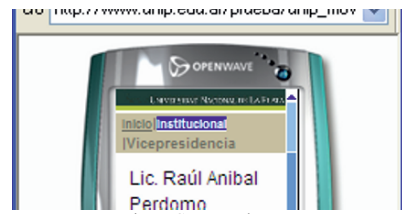


Fig. 5. Contextual menu

The original design considered the inclusion of an iconic bar for backward and forward browsing at the end of each page. However, in most mobile phones it did not display correctly.
Also in the heading, the logo of the UNLP is always visible in dark green. This logo will be modified to show only the initials, given the fact that in such reduced space the complete words do not display correctly.

mmeybodi@aut.ac.ir

The original design included a contextual menu which would display in the lower left corner of the screen, with many options.

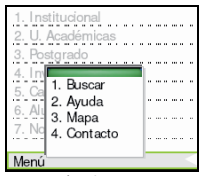


Fig. 6. Menu

However, WML does not support Javascript. We are currently analyzing alternatives to implement it.

The News section, one of the most visited of the traditional web site, was redesigned in order to show the information in a brief, concise and consistent way. A hyperlink, leading to a page with the news headings and their date, was included in the main page. Clicking on one of the news headings will display a brief comment on it. The display is as follows:



Fig. 7. News headings and details

V. Implementation Aspects

The site of the UNLP is developed in PHP, Perl on the side of the server, and on the side of the client uses Javascript, Flash and Applets written in Java. The database engine is PostgreSQL.

Regarding the mobile site, the prototype was programmed in WML, PHP4 and the editor of choice was VIM. The site itself is over a thousand lines of code and is located in a computer with Linux, is running an Apache server. Most of the information in the mobile website is dynamically generated, to keep consistency and facilitate maintenance.

Cascading Style Sheets were used but, based on the different usability tests performed on different cell phone models, during which sometimes it was impossible to browse the site, their convenience will be further analyzed.

VI. Details of the Usability Test

The test was developed taking into account the syntactic and semantic knowledge the users had. In this context, syntactic knowledge refers to the understanding of the use of mobile phones, while semantic knowledge refers to the comprehension of application aspects, in this particular case, regarding the UNLP and the information included about it specifically in the traditional website.

- **Group A:** individuals with little experience in the use of mobile phones and little knowledge of the website of the UNLP.
- **Group B:** individuals with little experience in the use of mobile phones and full knowledge of the website of the UNLP.
- **Group C:** individuals with vast experience in the use of mobile phones and no knowledge of the website of the UNLP.
- **Group D:** individuals with vast experience in the use of mobile phones and knowledge of the website of the UNLP.

Organization of the test

Before they accessed the mobile website of the UNLP, the participants were given a brief introductory talk about the prototype and the evaluation they were about to undergo. They were asked a series of questions in order to determine their profile and their experience in the use of cell phones and the website of the UNLP. After this, they began the interaction with the mobile website, completing the activities proposed.

There was an examiner present during this process, registering the results of the interaction as observed. The examiner also recorded any case in which a person requested their help.

Many different brands and models of mobile phones were used, among which were Sony Ericsson K300, Motorola E1 Rocker, Motorola V235 and Nokia N76.

Activities proposed

The activities proposed included punctual researching tasks, such as activities 1 and 2, and more general, like activities 3, 4 and 5.

- **Task 1:** Find out the name of the General Secretary of the UNLP.
- **Task 2:** Find out the e-mail address of the postgraduate secretary of the Faculty of Exact Sciences.
- **Task 3:** Find out which are the degree courses given in the faculty of Fine Arts.
- **Task 4:** Find out the news of this week in the UNLP.
- **Task 5:** Find out which are the postgraduate courses given in the Faculty of Humanities.

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Form design

The first section of the form focuses on an evaluation of the syntactic and semantic knowledge of the user, in order to establish a profile. The structure is as follows:

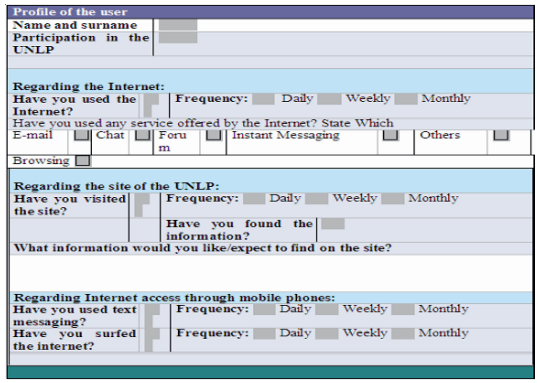


Fig. 8. Evaluation

The forms below describe the activities proposed, followed by options to specify the result, constituting the evaluation itself:

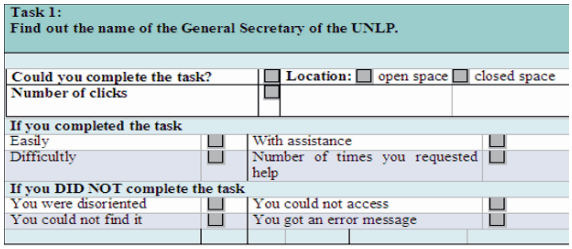


Fig. 9. Example of task

Finally, at the end of the form there is a space for the user to provide their opinions and suggestions. This space was designed in the following manner:

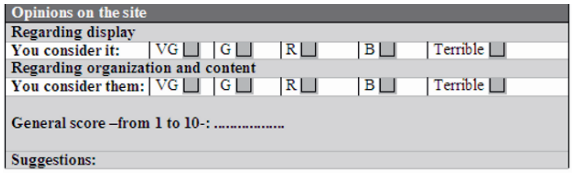


Fig. 10. Opinions section

VII. Results of the Experience

Group A: individuals with little experience in the use of mobile phones and little knowledge of the website of the UNLP.

- Took the longest -15 minutes- to complete the activities.
- Browsed everything up to the end, looking for a way to return to the previous page.
- Complained about activity 3 because the pages of the faculties are too extensive.
- Because they had very limited semantic knowledge, they had to be explained what institutional and academic unit mean. For this reason, activities 1, 2 and 3 were completed WITH help.
- Were alarmed when they saw error pages requesting the upload of a non-valid format.

Group B: individuals with little experience in the use of mobile phones and full knowledge of the website of the UNLP.

- Took less time and felt better.
- Read until the end to find out how to return to the previous page or, if the text was too long, went back to the main page.
- Complained about activity 3 because of the length of the pages and unintelligible icons.
- Requested access from the main page to the syllabuses of the courses.
-

Group C: individuals with vast experience in the use of mobile phones and no knowledge of the website of the UNLP.

- Were frustrated when they could not locate the back button.
- When playing with the keypad to accelerate accesses they were surprised when they unwillingly called one of the telephone numbers shown in the information.
- They felt it was slow.
- They complained of long pages. Hence, activity 3 took them some time to complete.
- They complained because the numerical shortcuts did not work properly and requested the back button to be in the cell phone.
- Had to be explained the concepts of academic unit and institutional.

Group D: individuals with vast experience in the use of mobile phones and knowledge of the website of the UNLP.

- Idem group C without need of explaining the concepts of academic unit and institutional.
- Requested access from the main page to the curriculum of the courses.

In short:

mmeybodi@aut.ac.ir

Profile	Group A
Activity 1	Difficulties. Requested help because they did not understand the concept
Activity 2	Difficulties. Requested help because they did not understand the concept
Activity 3	Difficulties. Requested help because they did not understand the concept . Could not find the back option in long pages
Activity 4	Had difficulties in returing to the main page, from the back button and from the context bar because it is difficult to distinguish which option is selected and where the user currently is
Activity 5	Had difficulties in returing to the main page, from the back button and from the context bar because it is difficult to distinguish which option is selected and where the user currently is
Comments	Could not find the back button . Complained about long pages. Could not understand the icons and the context bar. Were alarmed at the sight of a non-valid format error

Profile	Group B
Activity 1	Completed correctly
Activity 2	Completed correctly
Activity 3	Complained about long pages. Back option difficult
Activity 4	Completed correctly
Activity 5	Completed correctly
Comments	Could not understand the back icons either. Did not like long pages. Used the context bar to return to the last page

Profile	Group C
Activity 1	Requested an explanation of the concept
Activity 2	Requested an explanation of the concept
Activity 3	Had difficulties in returning. Complained about long pages. Pressed the wrong buttons on the phone, making unwilling phone calls. Wanted access from the numbers
Activity 4	Wanted access from the numbers. Had difficulties in going back to the main page
Activity 5	Good
Comments	Idem previous. Complained about the numerical shortcuts. Requested the back button to be in the cell phone

Profile	Group D
Activity 1	Good
Activity 2	Good
Activity 3	Idem group C
Activity 4	Idem group C
Activity 5	Good
Comments	Idem group C

Fig. 11. Summary tables

VIII. Conclusions

From this first test performed on real potential users, using physical mobile phones, we obtained critics and suggestions which will be taken into account in the stages to come.
Most of the participants agreed that:

- The icons are not correctly displayed, which causes the back button to be difficult to find. This had to be explained by the examiner present in the evaluation. Different alternatives to solve this problem will be analyzed.
- The context bar does not correctly display which option is selected and which is not. Many participants sought it to find the back button.
- It is impossible to go back from certain pages, for example, the long ones found when clicking in an academic unit. After a long time they arrive at the end, and cannot find the back option because the image is not clear.
- The most experienced in the use of cell phones want to use the keypad to go back, but this option is not always available and this frustrates them.
- They suggest that when the user enters academic unit he/she should find information regarding the address and telephone numbers. Its degree and postgraduate courses should be hyperlinks.
- The information displayed about the courses of studies should only be its name and length.
- Information regarding research activities should not be included, given the lack of normalized information.
- It is necessary to eliminate access to documents in formats which are not supported by cell phones, such as .pdf
- Some users were alarmed because occasionally, when trying to return to the previous page, the cell phone began calling a telephone number included in the information displayed.
- It is necessary to correct the administration of sessions. When a second participant accessed the mobile website, this remained in the page in which the previous user had finished the evaluation, and cannot return to the main page. This happens in the lists of academic units.

Given the amount and versatility of information available in the website, and its high update rate, it is not an easy task to determine the best organization possible and filter the content in accordance with the needs of the mobile version. Maintaining the consistency and update rate of both sides is not trivial, and although we foresee an automatization mechanism to obtain the interface of the mobile website, this implementation is not urgent, given the existence of the traditional website.

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mmeybodi@aut.ac.ir

Enhancing High School Science Through Sensor-Based Lab Exercises

Andrew Popichak, George Westinghouse High School, Brooklyn, NY 11201

Abstract – A participant's experiences as part of the RAISE program (Revitalizing Achievement by using Instrumentation in Science Education). This program involved Polytechnic University professors, graduate and undergraduate students, high school teachers and their students. It seeks to facilitate the implementation of sensor-based labs in the curriculum of high schools in the NYC school system with a particular emphasis in science courses subject to state-wide Regents Exams.

The present article is based on the experience of a high school teacher in George Westinghouse High School. The program was perceived to have a positive effect on student performance and pedagogy.

INTRODUCTION

Mandated laboratory exercises are part of the curriculum in some New York State science courses. Laboratory participation is prescribed in all Regents science courses and must be documented by completed lab exercises that are kept on file for several years and are subject to review by the state. The need for effective, engaging lab exercises naturally feeds into the possible use of sensors to enhance the illustration of scientific principals and the scientific method.

The enhancement of laboratories was carried under the auspices of RAISE [1-4]. Project RAISE (Revitalizing Achievement by Using Instrumentation in Science Education) is a program in which graduate and undergraduate students (Fellows) from Polytechnic University of New York assist high school science teachers primarily through the introduction and use of sensor-based equipment to enhance laboratory content and methods. In addition, the Fellows provide other forms of assistance to the teachers. RAISE Fellows have been employed in Living Environment, Active and Regents Physics, Marine Science, and Earth Science classes in four New York City inner-city high schools, three of which are located in Brooklyn and one in Manhattan [1]. RAISE is funded by the National Science Foundation (NSF)

RAISE THE PLANNING STAGE

During the spring of 2004, Dr. Vikram Kapila of Polytechnic University's mechanical engineering department approached the Westinghouse Assistant Principal of science and math, with the prospect of participating in the RAISE program should the program be funded. Several Westinghouse science teachers agreed to take part and that summer, along with teachers from three other high schools, we had our initiation. During the initiation, we had a week of introduction to the program, the sensor based labs and the RAISE fellows. These were both undergraduate and graduate students, and we would be working with them to upgrade our lab procedures. The orientation was needed, not only for the teachers, but for the Fellows; many of them had expectations of the high school students that would not be borne out in practice. While not long out of high school themselves, most had no experience in instruction and they would need to perform in front of students as the given lab exercise would need introduction, explanation and elaboration. Some of the effort during that first summer session was devoted to robotics. This turned out not to be as valuable as the laboratory practice and familiarization with the software and established exercises. The week of orientation also allowed for the student-teacher teams to sort out their schedules. The requirement to create an original lab in each discipline during this week gave the teachers and Fellows space to establish a working relationship and eased the transition to the classroom where flexibility was needed. Because the Fellows represented novel participant, they could also be a distraction if not handled sensitively.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 53–58.
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mmeybodi@aut.ac.ir

GEORGE WESTINGHOUSE HIGH SCHOOL

George Westinghouse is part of the NYC school system which contains some 1.1 million students and 80,000 teachers. The school, with an enrollment of 1200-1300 students, was being reoriented; from a vocational/technical school to an Information Technology (IT) technical school. Many of the incoming students had tested several years below grade level. At the same time, the IT emphasis ensured that the students gained significant computer skills, to the extent that they often demonstrated more expertise than their science teacher, in computers.

ABOUT THE AUTHOR

As a high school science teacher in his seventh year of teaching in the NYC school system and third year of involvement in the RAISE program, it seemed incumbent to revisit some aspects of evolution as an educator. Having come to this profession in his later working years, some reorientation of thinking was required. The author first career was as a metallurgical engineer for 7 years. Next he spent almost 20 years in health food retail. The acquisition of recent knowledge and techniques was necessary for to upgrade one's technical skills. The author's first experience as a teacher was three years as a lab instructor of undergraduates in an engineering college when he was pursuing his masters degree prior to working as a metallurgical engineer. That experience was positive and encouraged him to become a substitute teacher for two years. Substitute teaching helped to segue into full-time teaching. Ditto for B. S. and M. S. degrees in Material Science since this necessitated much experimental hands-on activity and thesis writing. Nevertheless, as the only physics teacher in a high school, the burden of providing meaningful state-mandated lab exercises was a solitary one. Given this situation, casting about for new modes and methods was necessary, if not sufficient.

PRIOR EXPERIENCE WITH SENSORS

My first exposure to computer based labs, equipment and software occurred, unintentionally, about five years ago (two years prior to RAISE) as part of a summer program under the auspices of STIR. STIR was organized at Lehman College to enhance the techniques of high school science teachers. A variety of science educators and vendors made presentations to a mix of high school and middle school science teachers from New York and New Jersey over the course of a week. As part of STIR, we were lead by a Vernier, Inc employee, using Vernier sensors and software and laptops supplied by the college for an entire day. As part of the same program, we also used Pasco, Inc. equipment for an entire day and the comparison was valuable. At the end of this program, each participant had to develop a lab using the equipment and techniques acquired during the summer.

Up till that time, almost all of my computer expertise (if use that word is accurate) was on Macintosh computer. This typically meant quickly getting lost when using Windows-based applications. However, it seemed apparent to this author that the Vernier equipment was more versatile and easier to use than the Pasco. At the end of the program, the grant under which the program was funded allowed for $400 of equipment to be purchased by each participant. Vernier sensors were the option I chose, which were then contributed to the high school stockpile of lab supplies.

The following school year, a one-day Saturday workshop using Vernier equipment was organized by STIR for chemistry teachers at New York University Washington Square campus using their labs. Again, it was quite impressive but I struggled to keep up as every so often I would press the wrong key or click on the wrong tab and get lost. . Out of necessity I acquired a personal laptop that spring and a video-tape tutorial was employed to develop some proficiency with computers.

THE PROGRESSION – YEAR ONE

After the summer week of training for RAISE, Westinghouse teachers were teamed up with Polytechnic Fellows. Rapidly, in the author's case, we developed a series of labs for a course designated Active Physics, a non-Regents course offered to 9th grade students in the New York school system. While not as rigorous as Regents physics, there is a certain level of competence necessary to which students must accommodate. We had four laptops at our disposal and sufficient sensors to perform the same exercises on each machine simultaneously. It was relatively easy to instruct the classes in the concepts of velocity, acceleration, mass, inertia, etc. using modified handbook lab exercises as well as some specially developed, particularly as related to heat phenomena. Simultaneously, other teachers and their partner Fellows, developed biological labs for Living Environment, a Regents course, and the equipment was shared through suitable scheduling. The presence of the Polytechnic Fellows in the classroom proved crucial to the performance of the lab exercises because of their experience, competence and their sincere desire to enrich the student's experience.

One of the biggest challenges is illustrating concepts in abstraction. A typical example is inertia. A properly designed lab can show that more force is needed to achieve the same acceleration as the object's mass increases. The relative ease with which acceleration can be measured with sensors, rather than inferred through

mmeybodi@aut.ac.ir

tedious calculations, contributes to the student comprehension, especially when they lack the rigorous mathematical background.

At first the students were nervous and challenged by the need to absorb a great deal of new material. As a way to ease into the new vocabulary we were trying to inculcate, we made extensive, selective use of physics video tapes. They reinforced the classroom material and served better than the textbook in grabbing the student's attention. Thus, when we came to perform a lab activity, we shared a vocabulary and the students had at least a vicarious experience to relate to the execution of the lab. Needless to say, with a limited number of laptops, competition for position often became paramount within a group of lab partners. Each group had approximately 6-8 students, which is more than the optimal 3-4. Once the groups sorted themselves out, the exercises would proceed and most finished collecting their data and writing their labs in the time allotted. Most of our students possess some computer skills and were able to navigate the screens and data tables as needed.

In comparison to conventional, non-sensor based labs, much less time was spent in student set-up and data recording. More time is needed for the instructor to insure that the necessary equipment is available and working properly and then to secure the apparatus at the end of the exercise. Through measurement of parameters such as acceleration, rather than calculation, student interest remains focused on the outcome rather than the means of a given exercise.

YEAR TWO

The academic year was prefaced again with a week of orientation at the end of the summer. Earlier, during the previous spring, various high school teachers were tasked with interviewing and assessing new undergraduate and graduate students seeking to participate in the program, as Fellows. The experience of the previous year gave critical insight in terms of evaluating the college students likely to positively interact with the high school students. This new academic year saw Active Physics replaced with Marine Science, another non-Regents course in the New York State curriculum. Again we had a week during the summer to become acquainted with Sensors and to pair up with Polytechnic Fellows. Again a graduate student was assigned to assist our George Westinghouse students. An undergraduate, was also involved and responsibilities were shared. There is no Vernier Lab manual for Marine Science and it was necessary to modify Biology and Chemistry labs. Additionally, we had to develop other labs to illustrate important concepts that are not covered in Vernier material. Generally, the labs were well received by the students even though there is no lab requirement for this course. In such a course, labs can provide a valuable diversion from the normal sequence of instruction as well as illustrating phenomena that would have to be taken on faith under other circumstances. An example is the diffusion of saline solution through animal membrane, in this case taken from a hard boiled egg. Such commonplace materials resonated with our students and clue them into complexities that occur in their everyday life that they would be unaware of, absent their science course.

At this point it should be noted that, simultaneously, other Westinghouse students were studying AP Chemistry. This course entailed using the same equipment and software. However, the facilities employed were outside Westinghouse, at City Tech College. The lab portion of this course required about half of the labs to be computer based. This added exposure in Chemistry helped to lift competence and confidence in the use of Vernier equipment in Marine Science. City Tech personnel were available to set up Chemistry labs and resolve the glitches that inevitably occur when novel programs are being instituted.

YEAR THREE

After our summer exposure to sensors and some new fellows, found us teaching a two semester course of Earth Science in one semester. This necessitated a regimen of two labs per week. Fortunately, the same Polytechnic Fellows were again selected for Westinghouse. This reconnection saved the time needed for two or more people to get on the same page. Again, while many handbook earth science labs were used, it was also found expedient to develop our own labs for subjects not treated by Vernier..

With the termination of the RAISE program, next year, we will lose the use of many of the sensors. This will constrict our ability to perform many of the labs we have developed. Because George Westinghouse is an IT school, computers are widely distributed and don't pose a bottleneck. Funding for sensors may be available along with normal laboratory supplies.

EPILOG

As the RAISE program reaches the end of its funding, the question of continuity becomes paramount. While use of most of the sensors and peripherals will be lost, the high school has acquired a core of a few fundamental sensors, the necessary software and lab manuals. This should allow for some sensor based labs and demonstrations to be performed. Additions to our inventory of sensors and peripherals might be funded through grant applications.

mmeybodi@aut.ac.ir

This summer, the author participated in a new program, WISE, (Summer Workshop in Instrumentation, Sensors and Engineering) (Iskander et al, 2007). WISE provided training in sensors for 20 middle and high school math and science teachers in a two-week residential institute at Polytechnic University. While this program does provide teachers of science with sensors and relevant training, there is no involvement with graduate and undergraduate students in the high schools.

REFLECTIONS ON RAISE

It is difficult to be objective about a subject after an involvement of three years or more. From my perspective, it seems that sensor based labs are inevitable for the reasons given in this document. Data collection through charts, tape recorders and various counters has existed for many decades; the advent of affordable computers paired with sensors is simply an extension of this process. What is needed is more exposure of high school teachers and laboratory associates to these techniques and provision of adequate training as needed. In the author's experience, the teachers involved in the RAISE program remained in the program and implemented the computer based labs in their schools. Monthly meetings kept the group current with regard to developments generated by teachers and the Polytechnic Fellows helping them. Likewise, in our school, the teachers exposed to the RAISE program have adopted the sensor based labs as the standard of their classrooms. The other science teachers did not adopt sensors in their labs which is understandable, given (1) the extent of the learning curve, (2) the lack of help or training, and (3) the paucity of sensors in the high school. While new lab space has been created, at this time a wholesale department-scale commitment to these types of labs is absent.

In the author's opinion the use of sensors and computers to execute the required exercises yields a superior learning experience that can enhance the student's understanding and help meet the state mandated standards for a subject [5]. For example, one phenomenon that has proven difficult to transmit is the heating curve of water. Trying to illustrate the series of events with charts fails with most students. Using a temperature sensor, frozen into a cup of water like a Popsicle and then slowly heated in a beaker to the boiling point of water yields a textbook-type graph that the typical student can relate to the phase changes taking place.

The use of sensors is clearly beneficial in high school science education. However teachers need training in order to use sensors Some sort of certification process should be considered for teachers who feel the need to adapt. This at a time when the use of sensors becomes easier as software and equipment design improves. Additionally, more types of phenomena can be studied as different sensors are developed. This begs the question, what are we waiting for?

ASSESSMENT

Objective assessment of the effectiveness of sensor based labs is difficult to come by. An independent observer ewas employed and reported preliminary findings in [6]. There are serious difficulties in assessing an effort like RAISE including:

1) Comparing baseline to subsequent classes assumes equality of student ability between years, this equality can be questioned due to normal variability in incoming classes and the small sample size.
2) In comparing RAISE to non-RAISE classes there are no comparison groups for some courses, most notably Regents Physics.
3) There may be variability between teachers regarding their grading practices.
4) Comparing RAISE and non-RAISE classes for the same teacher is problematic because of transfer of information from RAISE class to non-RAISE class. Also, some classes are not created as equal to others- for example, "honors" classes."

Data is available for one comparison group of RAISE and Non-RAISE taking Living Environment in Year-1 of RAISE (Fig. 1). The Percentage of Students that took the Regents Test was higher for the RAISE group. Of those students that took the test, a higher percentage of RAISE students passed and the average grade of RAISE students was higher.

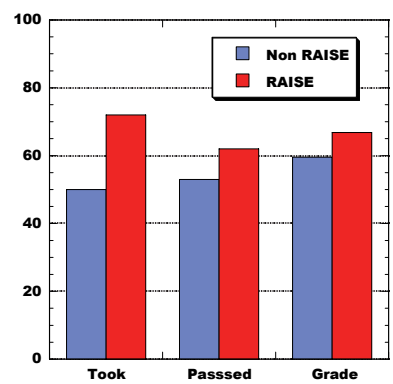


Fig. 1 – Effect of Participation in RAISE on Student Performance in Living Environment

mmeybodi@aut.ac.ir

CONCLUSIONS

Why go through the trouble of introducing computer labs when many tried and true procedures exist, developed by generations of science teachers? Why write new labs and have to proof them and obtain new materials and probes? Some possible answers to these questions are listed next.

Perhaps a school such as George Westinghouse, lacking in adequate lab space, electric service, water supply, gas supply, lab benches, operational hoods and safety equipment is still required to perform 30 exercises per year per student in Earth Science, Chemistry and Living Environment. In this event, computer based labs provide the ability to perform other than traditional experiments that illustrate the important aspects of the subject without more of an investment than for a few laptops and some probes and still meet state-mandated requirements. If computers are unavailable, exercises and hardware are available that adapt TI-83 calculators to collect and display data.

Perhaps it is crucial to demonstrate transient phenomena such as sound transmission through various materials or the progress of a chemical reaction. Absent specialized equipment such as oscilloscopes and colorimeters, it is virtually impossible to perform such procedures unless computer based labs are employed. Thus, the lab teacher and students can boldly go where no high school labs have gone before.

Rather than having to tediously plot data of dependent and independent variables, the software allows for data massage and makes printing of data and graphs very simple. It also enables the export of data into Excel documents. The various curve-fitting options take the student out of the realm of liner relationships.

Perhaps most importantly, computer based labs prepare and familiarize high school students with techniques applicable to advanced courses where such labs are requisite.

The availability of Sensors and the support of Polytechnic Fellows enabled several student groups to develop independent projects for the annual science fair and to compete on a city-wide basis with other students.

Because the labs are computer based, it is easy to save data when a lab can't be completed in the allotted time. It is also easy for groups to share data through using a computer connected to a DLP projector display.

To inject computer based labs into a curriculum need not be traumatic. The transition from what might be called analog labs can be gradual. Workshops are available for teacher training at reasonable cost and customer support is good. The acquisition of hardware can also be gradual. The laptops and desktops we employ are mostly castoffs of the technology department and the demands of data acquisition software are modest. Grants may be available from non-profit or governmental agencies. The key is to start. What is needed is a geometric increase where teachers and college students train other teachers in a given school until computer based labs become the standard. Recent science graduates are sure to have had prior exposure to such labs and often are well versed in sensors. They would be the logical choices to include in RAISE type programs.

It should be noted that teachers not exposed to the RAISE program have not exhibited much curiosity or enthusiasm for computer based labs. In fairness, established teachers may lack the skills outlined above. Certainly, most curriculums can be satisfied without the use of computers and sensors. Another factor is the training needed for lab associates. They need to become familiar with the equipment so that they can set up and tear down apparatus and determine when an item is not performing or broken. Some probes need special storage. Some need calibration some time before the actual performance of an exercise. Three years is not enough to establish an new culture, which is what the introduction of sensor-based labs represents. It is regrettable that RAISE was not further funded and the established base will not be available to other teachers in the NYC school system.

ACKNOWLEDGEMENTS

Revitalizing Achievement by using Instrumentation in Science Education (RAISE) is supported by the GK-12 Fellows Program of the National Science Foundation under grant DGE-0337668. Thanks are due to Drs. Vikram Kapila, Magued Iskander and Noel Kriftcher who are the project PI The author would like to thank Polytechnic University Fellows William Kok, Arsen Zavlayanov, and Edwin Yu, for their cooperation. Thanks are also due to the New York City Department of Education and to Dr. Raju Philip Assistant Principal of Science and math at George Westinghouse High School.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Blackboard Adoption and Adaptation Approaches

Anjli Narwani & Dr. Mohammed Arif,
British University in Dubai

Abstract- Multiple approaches can be employed to achieve the single objective of implementing the Blackboard Learning management system (LMS) in the UAE educational institution. In institutional management terms this could mean a pre-implementation plan and preparedness. In Project Management terms this could mean customized project life cycles. In institutional effectiveness terms this could mean post-implementation value and system utilization. This paper talks about the Blackboard Adoption and Adaptation approaches on these 3 levels, from the project implementer's perspective.

INTRODUCTION

If you are an educationist engaged with learning management systems, or a technologist involved in the implementation of learning management systems, or someone who identifies with the likes of any of these, it would not be difficult to recognize the challenges surrounding the successful execution of a learning management system (LMS) implementation in an educational environment. This paper is worth your read to know about approaches in action, which plausibly address the challenges from an implementer's perspective.

LEARNING MANAGEMENT SYSTEM IN DEFINITION

Learning Management System is a broad term that is used for a wide range of systems that organize and provide access to online learning services for students, instructors, and administrators. These services usually include access control, provision of learning content, communication tools, and organizations of user groups. Learning system(LS) is another term used synonymously with LMS.

Kaplan-Leiserson has developed an online e-learning glossary and provides the following definition of LMS:

Learning management system (LMS): Software that automates the administration of training events. The LMS registers users, tracks courses in a catalog, and records data from learners; it also provides reports to management. An LMS is typically designed to handle courses by multiple publishers and providers. It usually doesn't include its own authoring capabilities; instead, it focuses on managing courses created by a variety of other sources [1].

As an LMS, by principle, the Blackboard Learning system is designed for training online. In application, the 'teaching and learning' objectives take shape in the form of course delivery, learning objects management and evaluations in the context of Higher Educational Institutions. According to the Blackboard Inc. sources [2] ,the presence of the Blackboard LS is visible in the United Arab Emirates(UAE) and MEA Universities and educational institutions.

According to the DEST/JISC e-framework for Education and Research [3], the LMS technology implementation using a Service Oriented Approach (soa) is two-fold: one aspect dealing with the adoption of technology and the second with adaptation of environment to benefit from investment. However, this framework does not provide prescriptions to tackle the challenges in using the approach.

The challenges in the adoption and adaptation are a multitude; these can be classified as those related to

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 59–63.
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the information technology environment and infrastructure, the institutional readiness and organizational configuration, teaching pedagogy or the user-adoption and acceptance. With the aim to implement the Blackboard LS at a University in the UAE, the project objectives must address each of these classified challenges in addition to the project management challenges of managing resources, aligning project tasks to goals and schedules, monitoring progress and reporting.

One argument would favor that the initial step in the process of implementation would involve clear focus on the reasons for adoption; and the other that the higher precedence is for ensuring smooth and constructive adaptation of the intra-university environment. Yes, it would be ideal to first check Institutional readiness on all levels, ensure resources are in place, user base is trained and enthusiastic about the LMS and only then move forward towards LMS execution. However real-time circumstances rarely, if ever, give this luxury to the implementation.

Conditions for adoption of the system may be satisfied prior to implementation, or may be planned to be addressed during the implementation of the LMS. Some of these may include acquisition of technical resources and human resources for implementation, users' Information Technology (IT), in addition to that specific Blackboard, skills. Even before considering the detailed technical and human factors, is the important variable of Institutional Readiness.

Imagine, as the IT administrator at a University, the scenario, that within a few months the academia, all not even used to building lectures through power-point, must be equipped with an LMS; the decision being triggered by accreditation requirements. Yes, the decision would result in the University achieving a milestone, and becoming part of the knowledge management motion supported by educational technology; but for the implementation to be successful in its own right, this sudden move would require large efforts to help the university members (or users) and academic programs adapt to the adoption of the system.

THE FACTORS

The factors which impact the Blackboard LMS's adoption and adaptation of the learning environment, are not independent of the external economical, information technology, technological, cultural and social factors. The authors maintain the assumption from the implementer's stance that these exterior factors are supportive, if not all affirmative.

Institutional readiness and organization

It is not easy to ascertain the Institutional readiness of a University for the Blackboard LMS implementation, or even for the implementation of any other educational technology. Universities, like other higher educational institutions are being driven to make decisions to incorporate IT in teaching by many external and internal forces.

Blackboard LMS implementation would appear to be smooth if the university has either been using some form of course sharing and course building educational technology and academia is aware about online course delivery and communication tools. Management foresight to develop the use of IT in its framework is very positive for the Blackboard LMS adoption and adaptation.

The worst case scenario would be a university with little or no presence of IT tools in the current teaching methodology, or management not having envisioned the introduction of educational technology systems. In such a case the implementation would need to maximize its efforts towards bridging the digital divide.

Ideally the organizational structure should have room for introduction of roles or delegation of human capital for the purposes of Blackboard administration, Support to users, infrastructure

mmeybodi@aut.ac.ir

administration and Blackboard users' training.

IT environment and infrastructure

It would seem impossible to have a Blackboard implementation start off without at least an Intranet and client (instructor and student) PCs in place first. But let's not forget the wise saying "nothing is impossible", here its implication in a rather negative context. The presence of a well built and supported IT infrastructure is the key to the smooth completion of the technically bound tasks of the Blackboard implementation.

Teaching methods and pedagogy

Just like teaching and learning in their meanings represent the give and take of education, online learning technology and related concepts tend to align themselves accordingly. The element of IT providing the platform for this teaching – learning experience creates a complex compound made of student retention, faculty interest, subject expertise, course design, content, its construction, communication and quality. How to deduce the right combination of computer aided teaching & learning tools with face-to-face teaching is a challenge in front of the educationist and the program developers. The 3C-model of didactical components – Content, Communication and Construction, described by Kerres and Witt (2003) is a useful reference point for drawing optimal blended learning arrangements.

It is not expected for the LMS to intelligently evolve to adapt to the changing human learning needs, however, it can be desired to customize the system to adjust itself to procedures and requirements of the learning environment, specially the existing teaching pedagogy.

User adoption and acceptance

As is true for most IT solution introductions in an organization, in the course of implementation of an LMS at the University, there is a key driver, which also is ironically the key resistant – the user. Past research resonates this. E-learning models and IT Solution project implementation methodologies give heavy emphasis to the 'user' factor. The Blackboard learning management system, in its right, demands a cycle for the management of the human factors, including the promotion of user-adoption of the system and adaptation of the user base. Orienting the users to take advantage of the Blackboard LMS functionalities at their disposal requires training, support and promotion efforts.

The level of user interest is an interesting variable, which is difficult to deduce accurately, but even a gauge of its value describes the stage of adaptation to the technology. The level of utilization is the direct representative of adoption of the system. Prior IT adoption studies have included utilization as a dependent variable (e.g., [5], [6]). The utilization construct, when linked to technology performance, provides a metric of post-adoption usage behavior [7].

Each of the discussed factors is very closely linked to the local economical, social and technological cultures. One cannot ignore the external environment's impact on the internal web of project links if a true picture is required. Over time online learning management systems, institutions and IT solution developers have each, at their own pace and with their own styles, evolved to incorporate the respective best-fit methods, modules and mechanisms for purposes of effective delivery of courses online and management of learning outcomes systematically.

APPROACHES

Using action research methodology, through examination of five University implementations of the Blackboard LS in the UAE, an understanding of the current practices in tertiary universities was drawn. The Blackboard LMS implementation can be approached using a sequenced phase-wise approach or an ad-hoc approach. In a sequenced phase-wise project approach the Blackboard LMS implementation would generally include:

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- *The initiation phase*
  With the established aim for the implementation, implying Blackboard adoption the negotiation of contract, sign offs and project team allocation are features of this phase. The deliverable here is usually a scope of work (SOW) and contract.
- *The planning phase*
  The allocation of time, technical, human and financial resources in line with the scope defined. This phase deliverable defines the project schedule and allocation of resources.
- *The design phase*
  Blackboard LMS requirements from user, institution, program and infrastructure point of view are clarified and an architecture-level diagram produced along with an optional customization- requirements report. The customizations may be immediate, short-term or long-term requirements.
- *The technical deployment phase*
  Acquiring the technical resources, installation, configuration and customization based on the design phase deliverables for the purpose of the Blackboard deployment in the immediate future. The technical integrations may or may not be all customized and completed within the term before execution, depending on the requirements and feasibility.
- *The execution phase*
  This is the stage during which Blackboard is made accessible online to the user-base targeted by the Blackboard LMS execution deciders. In addition to a functional LMS a technical document for the administration, backup plan, monitoring and maintenance procedures should be produced.
- *The training phase*
  This may or may not be a one-time planned training. In addition to at-least an initial starter training, this phase should be accompanied with a training agenda and resourcing document as a deliverable.
- *The maintenance and support phase*
  The phase is on-going post-execution.

The phases might bear an overlap or at time some run in parallel. However, the deliverables would still be tangible and later phases would depend on outputs from the preceding ones, thus still maintaining a sequential characteristic.

The ad-hoc approach, as expected, does not have definite boundaries to identify phases, however, generic reference points would be:

- Initiation, usually signified by a contract sign-off
- The technical deployment, marking the physical implementation of the LMS architecture and ensuring the LMS is ready to be made available to users
- The execution, usually the formal launch of the system
- The training and/or support
- An upgrade

There is an overlap of challenging factors across the phases, and in many cases one modification in the approach of implementation has multiple effects on more than one element in the educational environment surrounding the LMS and directly on the Blackboard implementation itself. The tradeoffs between the positive and negative effects of certain decisions are subjective and variable.

More realistic approaches, which address the described challenges, do accommodate for some sequence phases and attempt to provide flexibility in project tasks based on circumstantial requirements.

The user engagement and the extent to which the user base embraces the Blackboard LMS is both a cause and effect of the Approach type used for Execution Phase (/ Point) :

The pilot approach: This approach not only gives the implementation the advantage of getting user feedback in time, it also provides the opportunity to the learning environment to adapt itself in one or more ways towards the use of Blackboard in teaching. A preferable approach for experienced

mmeybodi@aut.ac.ir

project management, with the option of building conducive conditions before a formal launch of the LMS is to first deploy a Pilot of the system using a sample user base. This user base sample may be selective, for instance a specific college or department, random sample or a selective blend of some colleges and department representatives. This approach gives the implementation the advantage of understanding and mapping the LMS to the real academic and institutional needs. The one visible downside is giving faculty an early-adopters seat which, not always, all users are ready for and this might open doors to early negative reaction. It is important here to pay close attention to ensure that the users give an un-biased opinion and are made aware that the Pilot system is not yet customized to the University's unique needs yet.

The partial launch approach: this is the second choice if the possibility of a Pilot does not suit the time-frame for a University's requirement, or if it is not possible to select a balanced sample. This approach provides the opportunity to learn the lessons from a selective part of the University before introducing the system to the rest. The advantages of this approach are similar to that of the Pilot approach; however the training and support efforts get called for sooner in this form of execution.

The in-one-go approach: launching the system across the entire university in one go would entail reactions of different levels depending on the size of the academia. This would be the classic case of least in-time user awareness and involvement and this approach usually maximizes the user resistance to the adoption of Blackboard. The most effort would be required for the training and support and to promote the adoption of the LMS by the teaching staff. Not an easy task, those who have seen this would agree.

"The comment that the "E" in E-learning should stand for "Evil" rather than Electronic has been heard around", Ms Poonam Chotelal an education technology specialist commented during a debate on e-learning and online exams; in order to ensure this "E" is perceived as "Enhanced" by a majority of the user base, it is important to give due emphasis to user-needs mapping in implementation of the Blackboard LMS. The best way to know what the user wants is to ask them. The first two execution approaches aim to leverage maximum user engagement before the complete revamp of the teaching style with the introduction of the LMS element.

Those Blackboard LMS project implementations with a consistent view on the factors affecting Blackboard adoption and adaptation, goal-orientation, blended with user base involvement and promotion of change management are more likely to succeed.

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mmeybodi@aut.ac.ir

An Empirical Study of Product Metrics in Software Testing

YOGESH SINGH[1] ARVINDER KAUR[2] BHARTI SURI[3]

1.Professor, University School Of Information Technology, G.G.S.Indraprastha University, Delhi, India,ys66@rediffmail.com.
2.Reader, University School Of Information Technology, G.G.S.Indraprastha University, Delhi, India.
3.Lecturer, University School Of Information Technology, G.G.S.Indraprastha University, Delhi, India,bhartisuri@gmail.com.

Abstract— Metrics are essential part of any software development organization to improve the quality of software. Measurement of a software process is a pre-requisite for planning and monitoring of cost effective test strategy. The analysis of trend shown by the metrics gives a way to take appropriate action for the process improvement and provide confidence in the software. Though various metrics exist for each phase of software life cycle but substantial work is needed in testing phase in particular.

This paper surveys and classifies various testing metrics. It also proposes some new software product testing metrics. The proposed metrics are analyzed over project data given by NASA[1].

I. INTRODUCTION

Measurement helps us in understanding, controlling & improving our process & product [2]. According to Kaner, "Measurement is the empirical, objective assignment of numbers, according is a rule derived from a model or theory, to attribute of object or events with the intent of describing them." [3]. Software metric [4,5,6] measures specific attribute of a software product or a software development process. Software metrics can be defined as, "The continuous application of measurement based techniques to the software development process and its products to supply meaningful and timely management information, together with the use of those techniques to improve that process and its products"[7]. Software metrics help in making many kind of predictions, assessment and trade-offs during software life cycle [8, 9, 10,11,12,13,14,15]. They help to minimize the risk as they provide quality input in decision making at various points in software life cycle. Software testing is a dominant part of software development process. Since software is constantly growing in size, power and complexity, extensive testing and evaluation of metrics may result in high level of confidence in software reliability. Software testing metric [16,17] is used to improve the software production & quality by quantifying testing activities or test process. They also provide insight stage of software as they are computed at the end of software development. If the results of test metrics are adequately used, they can help in improving quality of software. Also, for new projects, previous trends help in comparison & improvement of process.

The result from test metrics are used to understand the current status and helps in prioritizing various activities in a project to reduce the risk of schedule over-run on software releases. Due to new additions or testing done at client end next release of software is often modified and regression testing is done [18,19]. Data of previous testing helps in deriving test metrics which further helps in regression testing. After analyzing results of test metrics a chosen strategy for that software may not effective for some other software. Test metrics helps in measuring critical aspects of software, estimating accurate schedule, and cost and hence improve quality, productivity. It helps in controlling test process by providing input to software management.

The metrics can be classified as: product metrics, process metrics and project metrics. Product metrics describe the characteristics of the product e.g. Size, Performance, Efficiency etc. Process metrics describe the effectiveness and quality of the process that produce the software product e.g. Effort, Time, No. of defects found during testing. Project metrics describe the project's characteristics and execution e.g. No. of software developers, Cost, Schedule. In this paper we concentrate on product metrics.

The paper is organized into following sections. Section 2 overviews the research conducted so far in the area of product metrics in testing. Section 3 calculates some already existing product metrics in testing. Section 4 discusses proposed product metrics in testing with their observation and calculation over MDP data repository from NASA. Conclusions drawn from literature survey, classification and their analysis are being highlighted in the Section 5 of this paper

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 64–72.
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mmeybodi@aut.ac.ir

II. Related work

A number of useful product metrics in have been reported in the literature. Stark et. al.[20] evaluated a set of five metrics during testing phase of NASA's project e.g. software size, software reliability, test session efficiency, test focus, software maturity. They have examined trends for each metric and suggested that trends are more important than individual data points since by trend analysis and correlation, corrective action can be taken earlier in the process. They have also identified three more test metrics: subprogram complexity, test coverage and computer resource utilization. Their usage of the metric set throughout the testing effort leads to identify risks and problems early in the test process, minimizing the impact of problems. Further, by having a metric set with good coverage, managers were provided with more insight into the causes of problems, improving the effectiveness of response. According to them by maintaining the data and analysis a project can serve as benchmark which can be used for future project planning. Chen et. al. . [21] has applied set of test metrics in results of IBM Electronic Commerce Development (ECD) project. They gave the reason for low metric usage among organization that organization may not have control over measurement of results, data collection is difficult and time consuming and that no single metric is sufficient. They have recommended quality metric which compute quality of code, quality of product, test improvement, test effectiveness, time-to-market metrics like test time, test time over development time and cost to market metrics like test cost normalized to product size, test cost as ratio of development cost, cost per weighted defect unit. They have also modified and reused existing metric to guide further improvement like test improvement in product quality, test time needed normalized to size of product, cost per weighted defect unit. One new metric is also suggested: test effectiveness for driving out defects in each phase. They emphasize that metric should be computed regularly, defect arrival pattern should be studied and process should be improved accordingly. Quality metric in test phase has been used in [22] which analyzed relation between change volume of results and detected faults. They have proposed three metrics: procedures per module, conditions per module and loops per module as shown in table 1. Lewis [23] states that test metrics aims to make testing process more effective. He has listed metrics like: defect analysis, test effectiveness, development effectiveness, test automation, test cost test status and user involvement. The test metric should be measurable, independent, accountable and precise. The change volume of regularly measured results and fault information helps in improving accuracy and timeliness of quality management of testing. The quality metric can also be used to predict contents of change of program and to grasp the stability tendency in test phase. All the product metrics proposed and empirically calculated by various researchers are shown in table 1. We have discussed their purpose, measurement methodology and effectiveness.

III. CALCULATION OF SOME PRODUCT METRICS

We have calculated some product testing metric already given in literature and mentioned in table1 on the data available on the website of NASA Metric data program(MDP)- Repository access[1] on which data for certain projects is available. The data of the projects is comprised of certain files classifying the data with respect to various modules with their attributes and the different attributes of the defects associated with those modules. The Metrics Data Repository is used, from which three projects, i.e. KC1, KC2 and KC4 are taken for calculation of some already existing metrics: Quality code (QC) metric, quality of product (QP) metric, Test effectiveness for driving out defect in each test phase. Test effectiveness (TE) metric is also computed with the change that instead of weighted defects we have taken number of defects. Those already proposed metric are computed for which corresponding data was available. The results for these metrics are given in table 2.

For Quality of code, the expected result states that lower the value of QC, indicating fewer defects found, the higher the quality of code delivered. In the above calculated QC for the three projects, project KC3 has the maximum code quality as shown in fig. 1.

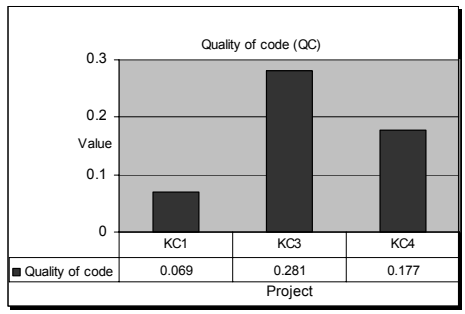


Fig. 1: Quality of code

For PQ, lower the value, indicating fewer defects found, the higher the quality of code delivered. Project KC1 has the maximum value of product quality as shown in fig. 2.

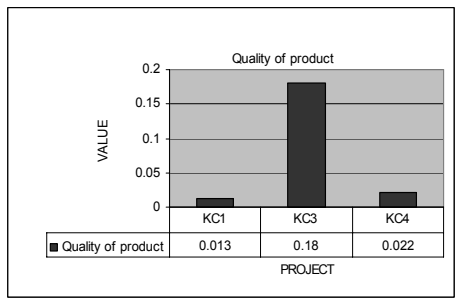


Fig. 2: Quality of product

Similarly, Test effectiveness in driving out defects in each test phase is shown in fig. 3. The higher this number, indicating a higher ratio of defects was closed of the appropriate problem

mmeybodi@aut.ac.ir

type, higher is the effectiveness of this phase to drive out the defects.

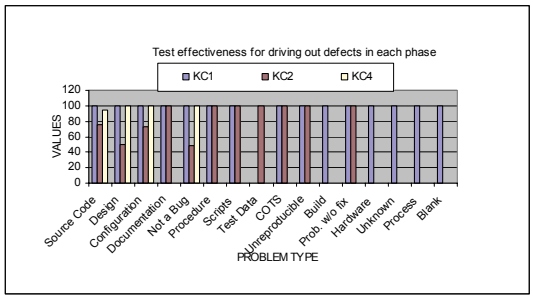


Figure 3: Test effectiveness for driving out defects in each phase

Figure 4 shows results of Test effectiveness metric which is calculated as ratio of defects closed and total no. of defects. As testing proceed it should approach to unity for an ideal case which is maximum for KC1.

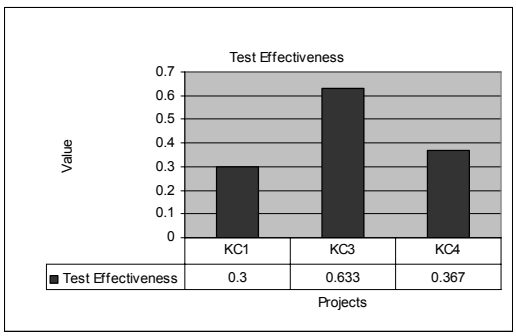


Figure 4: Test effectiveness

From these metric we conclude that project KC3 has best quality among the projects compared.

IV. PROPOSED METRICS

We have proposed following two metrics which further give insight into the software product and provide some more information about error report and test session efficiency at each stage. The first metric is: error focus that shows the relation between the error reports that are closed with a fix with respect to total number of error reports in the project.

$$\text{ErrorFocus} = (\text{Fixed_Closure_Error_Report})/(\text{Total_Error_Report})$$

Error reports are the reports that are generated for each type of error found in the system. Reasons for closure of error reports can be: fix, duplicate, obsolete and reject. Fixed_Closure_Error_Report denotes the total number of error reports for the whole project which are closed with a fix. Total_Error_Reports are the total number of error reports generated. The purpose of ErrorFocus metric is to provide information about effectiveness of testing in fixing defects.

We further computed this metric on the data available from NASA MDP database and fig. 5 demostrate the results.

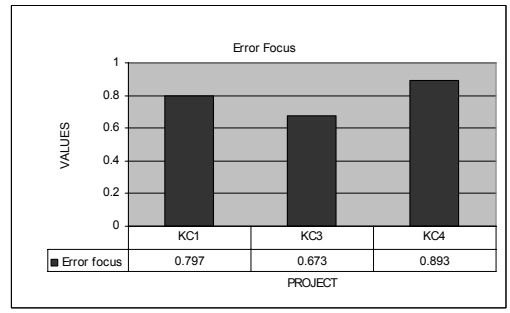
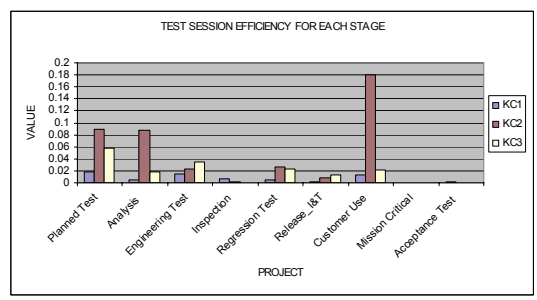


Fig.5 Error Focus

The second metric is Test session efficiency (TSE) for each stage that captures the relation between numbers of weighted defects found at each stage and the number of added or changed source lines of code.

$$TSE=(Z_{stage})/CASLOC$$

Where, Z_{Stage} denotes the total number of weighted defects at each stage found in the product after release and $CASLOC$ denotes the number of changed or added source lines of code. The session which results highest value for test session efficiency contributes most in finding defects. The purpose of test session efficiency (TSE) is to compare the effectiveness of different stages of testing. TSE for MDP data is computed for three projects and is shown in fig. 6.



Fig, 6. Test session efficiency

In project KC1, planned test stage contributes most in finding defects. In KC3, customer use stage finds most defects and in KC4 also planned test stage has maximum TSE value.

V. CONCLUSION

This paper discusses the existing metrics for software testing focusing on product metrics in testing. The carefully selected testing metric suite is beneficial in measurement and provides useful information to for decision making and future improvements. Hence, concentration should not be placed on

mmeybodi@aut.ac.ir

the specific concerns of the individual metric as one metric is not sufficient to measure testing process efficiency.

The paper summarizes existing product metrics in testing and uncovers gaps in existing research. A set of software testing metrics at product level have derived/proposed intuitively with their calculation and graphical representation. In this work we have calculated the proposed metrics value, but same metrics can be calculated on other established projects and are open to further research.

TABLE 1
COMPARISON OF SOFTWARE TESTING PRODUCT METRICS

Year and Size of project	Test Metric	Definition/ Purpose	Formula	Effect
2004 *IBM ECD Project	Quality code (QC)	It captures the relation between the number of weighted defects and the size of product release. Purpose is to deliver a high quality product.	$W_{TP}+W_F$/KCSI	The lower the value of QC, indicating fewer defects or less serious defects found, the higher the quality of code delivered.
2004 *IBM ECD Project	Quality of the Product (QP)	It shows the relation between the number of weighted defects shipped to customers and size of the product release. Purpose is to deliver a high quality product.	W_F/KCSI	A low number of QP indicates fewer defects, or less serious defects were shipped, implying a higher quality of the code delivered by the test teams.
2004 *IBM ECD Project	Test Improvement (TI)	It shows the relation between the number of weighted defects detected by the test team during testing and the size of the product release. Purpose is to deliver a high quality product.	W_{TTP}/KCSI	The higher the number, indicating more defects or more important defects were detected the higher the improvement to the quality of the product which can be attributed to the test teams.
2004 *IBM ECD Project	Test effectiveness (TE)	It shows the relation between the number of weighted defects detected during testing and the total number of weighted defects in the product. Purpose is to deliver a high quality product.	$W_T/(W_{TP}+W_F)$*100%	The higher the TE, indicating a higher ratio of defects or important defects were detected before release, the higher is the effectiveness of the test organization to drive out defects.
2004 *IBM ECD Project	Test time (TT)	It shows the relation between time spent on testing and the size of the product release. Purpose is to decrease time-to-market.	T_T/KCSI	The lower this number, the less time required by the test teams to test the product.
2004 IBM ECD Project	Test time over development time(TD)	It shows the relation between time spent on testing and the time spent on developing. Purpose is to decrease time-to-market.	T_T/T_D*100%	The lower this number, the lower is the amount of time required by the test teams to test the product compared to the development team.
2004 *IBM ECD Project	Test cost normalized to product size (TCS)	It shows the relation between resource or money spent on testing and the size of the product release. Purpose is to decrease cost-to-market.	C_T/KCSI	The lower this number, the lower is the cost required to test each thousand lines of code.
2004 IBM ECD Project	Test cost as a ratio of development cost (TCD)	It shows the relation between testing cost and development cost of the product. Purpose is to decrease cost-to-market.	C_T/C_D*100%	The lower this number, the lower is the cost required by the test teams to test the product compared to development team.
2004 *IBM ECD Project	Cost per weighted defect unit (CWD)	It shows the relation between money spent by test team and the number of weighted defects detected during testing. Purpose is to decrease cost-to-market.	C_T/W_T	The lower this number, the lower is the cost of finding one defect unit, and the more cost-effective is the test process.
2004 *IBM ECD Project	Test improvement in product quality.	It shows the relation between the number of weighted defects detected and the size of the product release.	W_P/KCSI	The higher this number, the higher is the improvement of the quality of the product contributed during this test phase.
2004 *IBM ECD Project	Test time needed normalized to size of product.	It shows the relation between time spent on testing and the size of the product release.	T_{TP}/KCSI	The lower this number, the less time required for the test phase relatively.
2004 *IBM ECD Project	Test cost normalized to size of product.	It shows the relation between resource or money spent on the test phase and the size of the product release.	C_{TP}/KCSI	The lower this number, the lower is the cost required to test each thousand lines of code in the test phase.
2004 *IBM ECD Project	Cost per weighted defect unit.	It shows the relation between money spent on the test phase and the number of weighted defects detected.	C_{TP}/W_T	The lower this number, the lower is the cost of finding one defect unit in the test phase, and the more cost-effective is this test phase.

mmeybodi@aut.ac.ir

2004 *IBM ECD Project	Test effectiveness for driving out defects in each test phase.	It shows the relation between the number of one type of defects detected in one specific test phase and the total number of this type of defect in the product.	$W_D/(W_D+W_N)*100\%$	The higher this number, indicating a higher ratio of defects or important defects was detected in the "appropriate" test phase, the higher is the effectiveness of this test phase to drive out its target type of defects.
815,362 SLOC of NASA's MCCU project, 1992	Software size	Measured by a count of source lines of code (SLOC). Goal is to show the risks to the system over time.	—	Large increases in software size late in the development cycle often result in increased testing and maintenance activities.
815,362 SLOC of NASA's MCCU project, 1992	Software reliability	It is the probability of failure free operation of a computer program for a specified time in a specified environment.	Z(t) = (h)exp(-ht/N)	The decreasing failure rate represents the growth in the reliability of software.
815,362 SLOC of NASA's MCCU project, 1992	Test session efficiency	Goal of the test session efficiency metric is to identify trends in the scheduled test time's effectiveness	SYSE= Active Test Time/Scheduled Test Time TE= Total no. of good runs/Total runs	Both should be greater than 80%.
815,362 SLOC of NASA's MCCU project, 1992	Test focus	Goal is to identify the amount of effort spent finding and fixing real faults versus the effort spent either eliminating false defects or waiting for a hardware fix.	TF = No. of DRs closed with a software fix/Total no. of DR	In an ideal case Test Focus approaches unity as testing proceeds.
815,362 SLOC of NASA's MCCU project, 1992	Software maturity	Goal is to quantify the relative stabilization of a software subsystem (ii) To identify any possible over-testing or testing bottlenecks by examining the fault density of the subsystem over time. Three components are: T, O, H.	T = Total no. of DRs changed to a subsystem/1000 SLOC O = No. of currently open subsystem DRs/1000 SLOC H = Active test hours per subsystem/1000 SLOC	Graph of T versus H should begin with a near_infinite slope and approach a zero slope. Otherwise a low quality subsystem is indicated and should be investigated. Graph of O versus H is an indication of low rapidly faults are being fixed. It should begin with a positive slope, then as debuggers begin to correct the faults, the slope should become negative
[20]	Subprogram complexity	Goal is to identify the complexity of each function and to track the progress of function with a relatively high complexity as they represent the highest risk.	% if functions with a complexity greater than a recommended threshold.	A positive trend indicates the needs to re-evaluate the software change philosophy, possibly resulting in some re-design. A negative trend indicates the changed function had been redesigned to reduce complexity and increase maintainability.
[20]	Test coverage	Goal of the metric is to examine the efficiency of testing over time.	% of code branches that have been executed during testing	—
[20]	Computer resource utilization	Goal is to estimate the utilized capacity of the system prior to operations to ensure that sufficient resources exist.	—	—
[22]	Procedures/Module		No. of procedure per module	Using results with the fault information, progress situation can be grasped quickly and accurately
[22]	Conditions/Module		No. of conditions per module	
[22]	Loops/module		No. Of loops per module	
[23]	Defect analysis	Distribution of defect causes	Histogram, Pareto	Every defect is analyzed to answer questions about root cause, how detected, when detected, who detected.
		Number of defects by cause over time	Multi-line graph	The causes are analyzed.
		Number of defects by how found over time	Multi-line graph	Defects are analyzed with respect to time.
		Distribution of defects by module	Histogram, Pareto	Defects are analyzed with respect to module.
		Distribution of defects by priority (critical, high, medium, low)	Histogram	Defects are analyzed with respect to priority.

mmeybodi@aut.ac.ir

		Distribution of defects by functional Area	Histogram	--
		Distribution of defects by environment (platform)	Histogram, Pareto	Defects are analyzed with respect to environment.
		Distribution of defects by type (architecture, connectivity, consistency, database integrity, documentation, GUI, installation, memory, performance, security, standards and conventions, stress, usability, bad fixes)	Histogram, Pareto	Defects are analyzed with respect to type.
		Distribution of defects by who detected (external customer, internal customer, development, QA, other)	Histogram, Pareto	Defects are analyzed with respect to persons involved.
		Distribution by how detected (technical review, walkthroughs, JAD, prototyping, inspection, test execution)	Histogram, Pareto	Defects are analyzed with respect to phase of detection.
		Distribution of defects by severity (high, medium, low defects)	Histogram	Defects are analyzed with respect to severity.
[23]	Development effectiveness	Average time for development to repair defect	Total repair time ÷ number of repaired defects	It gives information about how well is development fixing the defects.
[23]	Test automation:	Percent of manual vs. automated testing	Cost of manual test effort ÷ total test cost	To find the effort expended on test automation.
[23]	Test cost:	Distribution of cost by cause	Histogram, Pareto	To find the resources and time spent on testing.
		Distribution of cost by application	Histogram, Pareto	--
		Percent of costs for testing	Test testing cost ÷ total system cost	To compare testing cost.
		Total costs of testing over time	Line graph	--
		Average cost of locating a defect	Total cost of testing ÷ number of defects detected	--
		Anticipated costs of testing vs. actual cost	Comparison	To analyzed deference between actual and estimated cost.
		Average cost of locating a requirements defect with requirements reviews	Requirements review costs ÷ number of defects uncovered during requirement reviews	To analyzed cost of finding requirement defects using requirement review.
		Average cost of locating a design defect with design reviews	Design review costs ÷ number of defects uncovered during design reviews	To analyzed cost of finding design defects using design review.
		Average cost of locating a code defect with reviews	Code review costs ÷ number of defects uncovered during code reviews	To analyzed cost of finding code defects using code review.
		Average cost of locating a defect with test execution	Test execution costs ÷ number of defects uncovered during test execution	To analyzed cost of finding execution defects using test execution.
		Number of testing resources over time	Line plot	--
[23]	Test effectiveness	Percentage of defects discovered during maintenance	Number of defects discovered during maintenance ÷ number of defects uncovered	To find how well is testing doing.
		Percentage of defects uncovered due to testing	Number of detected errors through testing ÷ total system defects	To find how well testing is done.

mmeybodi@aut.ac.ir

		Average effectiveness of a test	Number of tests ÷ total system defects	To find which test case is more effective.
		Value returned while reviewing Requirements	Number of defects uncovered during requirements review ÷ requirements test costs	To analyzed effectiveness of requirement review.
		Value returned while reviewing design	Number of defects uncovered during design review ÷ design test costs	To analyzed effectiveness of design review.
		Value returned while reviewing programs	Number of defects uncovered during program review ÷ program test costs	To analyzed effectiveness of program review.
		Value returned during test execution	Number of defects uncovered during testing ÷ test costs	To analyzed effectiveness of testing.
		Effect of testing changes	Number of tested changes ÷ problems attributable to the changes	To analyzed effectiveness of testing with respect to modification.
		People's assessment of effectiveness of testing	Subjective scaling (1–10)	To analyze people perspective.
		Average time for QA to verify fix	Total QA verification time ÷ total number of defects to verify	--
		Number of defects over time	Line graph	To analyze defect with respect to time.
		Cumulative number of defects over time	Line graph	--
		Number of application defects over Time	Multi-line graph	--
[23]	Test extent	Percentage of statements executed	Number of statements executed ÷ total statements	To find the percentage of testing done so far.
		Percentage of logical paths executed	Number of logical paths ÷ total number of paths	To analyze coverage with respect to path over time.
		Percentage of acceptance criteria tested	Acceptance criteria tested ÷ total acceptance criteria	To analyze acceptance testing.
		Number of requirements tested over time	Line plot	To analyze how many requirements are covered by testing.
		Number of statements executed over time	Line plot	To analyze coverage with respect to code over time.
		Number of data elements exercised over time	Line plot	To analyze coverage with respect to data elements over time.
		Number of decision statements executed over time	Line plot	To analyze coverage with respect to decision node over time.
	Test status	Number of tests ready to run over time	Line plot	To find where we are in the testing process.
		Number of tests run over time	Line plot	--
		Number of tests run without defects uncovered	Line plot	--
		Number of defects corrected over time	Line plot	--
	User involvement	Percentage of user testing	User testing time ÷ total test time	Finding how much the user involved in testing.

W_{TP} – no. of weighted defects found in the product under test (before official release)
W_F – no. of weighted defects found in the product after release.
KCSI – no. of new or changed source lines of code in thousands.
W_{TTP} – is the no. of weighted defects found by the test team in the test cycle of the product.

mmeybodi@aut.ac.ir

W_T – no. of weighted defects found by the test team during the product cycle.
T_T – no. of business days used for product testing.
T_D – no. of business days used for product development.
C_T – total cost of testing the product in dollars.
C_D – total cost of developing the product in dollars.
W_P – no. of weighted defects found in one specific test phase.
T_{TP} – no. of business days used for a specific test phase.
C_{TP} – total cost of a specific test phase in dollars.
W_D – no. of weighted defects of this defect type that are detected after the test phase.
W_N – no. of weighted defects of this defect type (any particular type) that remain uncovered after the test phase (missed defects)
Z(t) – instantaneous failure rate.
h – Failure rate prior to the start of testing
N – no. of faults inherent in the program prior to the start of testing.
SYSE – System Efficiency
TE – Tester efficiency
DR – Discrepancy Report
TF – Test Focus
T – Total Density
O – Open Density
H – Test Hours

TABLE 2
COMPARISON OF CALCULATED RESULTS ON EXISTING METRICS

S.No.	Name of Test Metrics	Project KC1	Project KC3	Project KC4
1.	Quality Code (QC)	0.069	0.281	0.177
2.	Quality of product	0.013	0.180	0.022
3.	Test effectiveness in driving out defects in each test phase:			
	Source Code	99.55	76.129	94.35
	Design	100	50	100
	Configuration	100	73.076	100
	Documentation	100	100	--
	Not a Bug	100	48.148	100
	Procedure	100	100	--
	Scripts	100	100	--
	Test Data	--	100	--
	COTS	100	100	--
	Unreproducible	100	100	--
	Build	100	--	--
	Prob. w/o fix	100	100	--
	Hardware	100	--	--
	Unknown	100	--	--
	Process	100	--	--
	Blank	100	0	--
	Hardware	100	--	--
	Unknown	100	--	--
	Process	100	--	--
	Blank	100	0	--
4.	Test Effectiveness (TE)	.3	.633	.367

mmeybodi@aut.ac.ir

TABLE 3
COMPARISON OF CALCULATED RESULTS ON PROPOSED METRICS

S.No.	Name of Test Metrics	Project KC1	Project KC3	Project KC4
1	Error Focus	.797	.673	.893
2	Test Session efficiency for each stage			
	Planned Test	0.018	0.089	0.058
	Analysis	0.005	0.088	0.018
	Engineering Test	0.015	0.023	0.035
	Inspection	0.006	0.002	-
	Regression Test	0.005	0.026	0.023
	Release_I&T	0.001	0.008	0.014
	Customer Use	0.013	0.180	0.022
	Demo	1.4 x 10-4	-	0.004
	Mission Success	7.2 x 10-5	-	-
	Mission Essential	7.2 x 10-5	-	-
	Mission Critical	0.0002	-	-
	Acceptance Test	0.002	-	-

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mmeybodi@aut.ac.ir

A Dual-Mode Collaborative Teaching and Learning Classroom Environment

C. N. Thai
University of Georgia
Biological and Agricultural Engineering Department
Athens GA 30602-4435
E-mail: thai@engr.uga.edu
Web site: http://www.engr.uga.edu/people/thai

Abstract- **As "hand-written notes" and "personal narrations" are the most natural tools to record, review, integrate and develop our own learning process, this article describes a collaborative learning and teaching environment integrating the use of Pen Tablets and multimedia technologies at the student/teacher level with the goal of achieving active learning for students in the classroom. An innovative hardware and software integration of the PCI NetSupport Manager Suite, TechSmith Camtasia Studio and Wacom Pen Tablets was implemented to provide both "teacher-centric" and "student-student collaborative" modes in this classroom. As this project was just implemented in mid-August 2007, only preliminary assessment results are presented in this article.**

I. Introduction

One of the thrusts in the UGA/Biological & Agricultural Engineering Department curriculum is to promote the active learning aspects for our engineering students during classroom lectures as well as during laboratory experiments needed for the course [1]. Based on Student Technology fees, departmental and collegial funds, two collaborative classrooms were created to achieve the first goal [2]. One classroom (Room 219) currently has 35 workstations for students and a teacher station connected to an isolated 1.0 Gbps LAN and the other classroom (Room 310) is similarly equipped but with only 12 student workstations. These PCs are equipped with Windows Vista and other specialized software to allow synchronous collaborative interactions between teacher-students and student-student for in-class projects, as well as for receiving classroom instructions from experts located outside the Athens campus via videoconferencing technologies. Starting in Fall 2005, we incorporated the use of a Tablet PC by the teacher in developing hand-written materials that are best created during class time, such as deriving computer algorithms interactively with students inputs, going over solutions to quizzes, tests or review sessions [3], [4]. This Tablet PC was also used to directly control remote lab equipment and to send its "apparent" desktop, along with hand-written annotations, to the student PCs thus allowing the students to "see" the operation of the remote lab equipment as well to operate the remote equipment by proxy via the Teacher Desktop Station (see Fig. 1).

As "hand-written notes" and "personal narrations" are the most natural tools to record, review, integrate and develop our own learning process, we are continuing the existing project to include the use of Tablet PCs (or Pen Tablets with Desktop PCs on Windows Vista) and multimedia technologies at the student level with the goal of achieving more active and hopefully deeper learning for students in the lecture hall as well as in the laboratory. This project responds to the priorities set by the BAE department as well as the University of Georgia on experiential learning, on graduate education, on biotechnology and incorporation of instructional technologies into the classrooms and laboratories.

II. Project Description

Reference [5] listed that "learning to listen carefully, think critically, participate constructively, and collaborate productively to solve common problems are vital components of an education for citizenship in the twenty-first century". Thus to provide such a classroom environment for interactive and collaborative education and from our previous experiences in designing and teaching in such a classroom, it was concluded that we needed both a "teacher-centric" architecture to deliver materials from teacher to students, and also a "collaborative e-chalkboard" where students could post individual works to be contrasted side by side by the teacher and/or to be collaborating with other class mates, because while "collaboration" is to be fostered to yield better subject matter comprehension and retention, student discipline and interest still need to be supervised in any real classroom.

A. IT Architectures Chosen

Currently there are several interactive instruction software that emphasize one or the other of the two aspects, "teacher-centric" such as "DyKnow-Vision" and "NetOp-School" while "GroupScribbles" and "TeamSpot" offer elegant collaborative solutions (this list is by no means exhaustive):

a) DyKnow-Vision (http://www.dyknow.com/products/vision/).
b) NetOp-School (http://www.netop.com/netop-8.htm).
c) GroupScribbles (http://groupscribbles.sri.com/).
d) TeamSpot (http://www.tidebreak.com/).

Personally, I think that the architecture offered by GroupScribbles is the most elegant one, however right now it can only support the sharing of small Post-It type of notes and for real classroom teaching we need to be able to share regular windowed applications. TeamSpot is more oriented towards

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 73–78.
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mmeybodi@aut.ac.ir

professional work environments so it does not yet have "student management" tools like in Dyknow Vision or NetOp School. For many years, our department had used the NetSupport Manager Suite ("Tutor" and "Control" in the company-recommended "teacher-centric" mode until we got introduced to "GroupScribbles" thanks to a webminar offered by the Hewlett-Packard Company at (http://h20325.www2.hp.com/blogs/highered/archive/2006/11/17/1948.html). This webminar made us realize that the 2 NSM tools "Tutor" and "Control" can be combined "innovatively" to provide both "teacher-centric" and "collaborative e-chalkboard" modes in an "undocumented" way with pen and audio technologies. Why "undocumented"? It was because the software maker (NetSupport Limited) did not themselves envision for the software suite to be used in this manner.

Figure 1 described the IT architecture used for the BAE Interactive/Collaborative Classroom (Room 310) starting Fall 07 in its "teacher-centric" mode. The NSM Tutor (also commercially known as NetSupport School) deployment from the Teacher Tablet PC and Teacher Desktop PC to Student PCs was a "standard procedure" for interacting with students described in more details in [1]. In the "teacher-centric" mode of our instructional system, the main task for the Teacher Desktop PC was to deliver lecture materials (i.e. the Teacher's Desktop view) to each student PC in their own application windows, thus allowing students to create their own personal notes using their Pen Tablets and the Windows Snipping Tool.

The Teacher Desktop PC secondary task was to use TechSmith Camtasia Studio to record the Lecture materials along with the teacher narrations and other verbal interactions within the classroom. These Camtasia recordings could be processed into Flash movies and published on the UGA BlackBoard Vista CMS system within 1.5 to 2 hours after classes for students to access 24/7.

As its primary task, the Teacher Tablet PC also used NSM Tutor and Camtasia Studio but to monitor and record student activities by "scanning" their desktops sequentially for a given time period during each scanning cycle. These recordings were reviewed by the instructor at a later time to document the time spent "on-task" by the students and also to observe the problem-solving approaches used by students during planned independent problem-solving activities.

The Teacher Tablet PC secondary task is to "activate" the NSM Control tools on selected student PCs as part of the sequence to get our instructional system into the two "collaborative" modes to be described in details below.

For the first mode, called "collaborative community work", Figure 2 described the IT architecture to deploy the NSM Control tools on the student PCs in order to let them access the Teacher Desktop PC, essentially serving as an E-chalkboard, where the community work would be realized. There were several steps needed to establish this mode of operation:

1. The instructor started the process on the Teacher Desktop PC by opening the needed application software where the community work would be performed from then on.
2. Via the Teacher Tablet PC, the instructor remotely executed the start of the NSM Control tools, on selected or all student PCs, which would appear on each student PC as a new windowed application.
3. On each student PC, this NSM Control application window was configured to contain a single icon corresponding to the Teacher Desktop PC and it would be entirely up to the student to want to connect to the Teacher Desktop PC in order to contribute to the community work or just to watch the community work unfolding on a large projector screen in front of the class (see Fig. 2).
4. Then, if the "contributing" student double-clicked on the Teacher Desktop icon, a new application window would pop up, showing the contents of the Teacher PC Desktop. At this point, the "contributing" student would be sharing into the Teacher PC desktop via his or her local keyboard and mouse/pen, and he or she

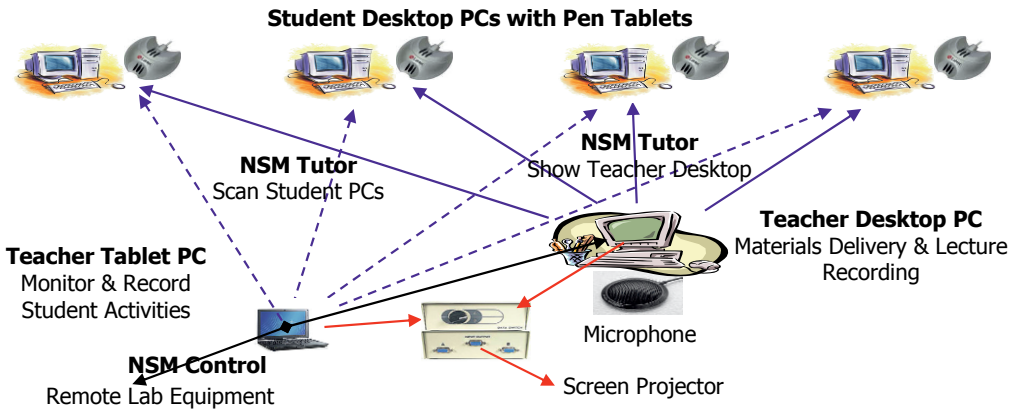


Figure 1. IT architecture for Interactive/Collaborative Classroom ("Teacher Centric" mode).

mmeybodi@aut.ac.ir

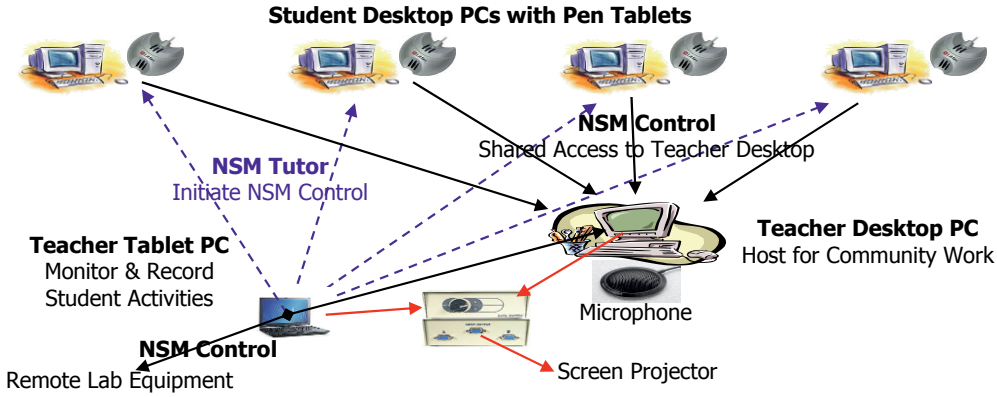


Figure 2. IT architecture for Interactive/Collaborative Classroom ("Collaborative Community Work" mode).

could also resize this window as needed in order to contribute efficiently to the community work in progress.

5. However there is a limit of 10 simultaneous student connections imposed by the Windows Vista Operating System, thus when some students had finished with their contributions, they would need to disconnect so as to allow other students to have their turns to contribute.

The second "collaborative" mode allowed "student initiated works" to be modified by the rest of the class in the following manner (see Fig. 3):

1. Let's say that the class was divided into Demo Students who were willing to showcase their current works and Contributing Students who were willing to offer constructive features to the works being shared. The instructor would start the process on the Teacher Desktop PC by using NetSupport Tutor to "View in Share Mode" each of the Demo Students PCs [2]. This action would result in the creation of several application windows on the Teacher Desktop PC, each window corresponding to the Desktop of each "Demo Student" PC.
2. Next, via the Teacher Tablet PC, the instructor remotely executed the start of the NSM Control tools, on all Contributing Student PCs, which would appear on each Contributing Student PC as a new NSM Control application window.
3. Similarly as for the first "collaborative" mode, this NSM Control application window was configured to contain a single icon corresponding to the Teacher Desktop PC and as before, it would be entirely up to the student to decide to connect to the Teacher Desktop PC in order to contribute to the Demo Students' works.
4. Then, if the Contributing Student double-clicked on the Teacher Desktop icon, a new application window

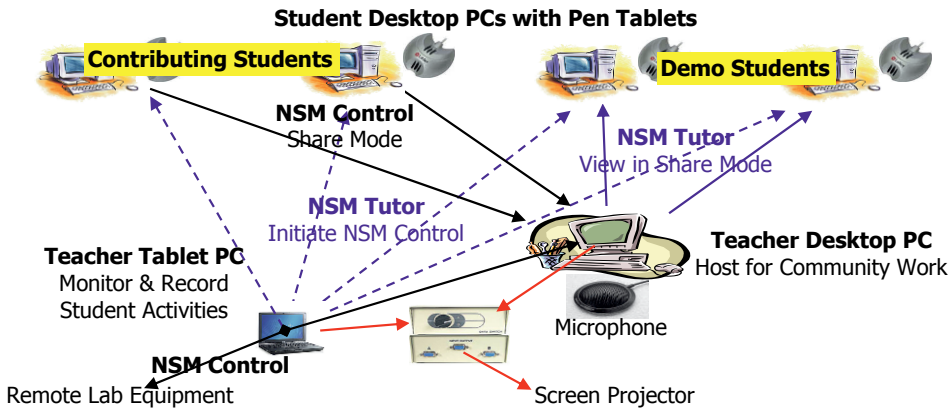


Figure 3. IT architecture for Interactive/Collaborative Classroom ("Student Initiated Work with Class Contribution" mode).

mmeybodi@aut.ac.ir

would pop up, showing the contents of the Teacher PC Desktop. At this point, the Contributing Student would choose which Demo Student's desktop, i.e. which application window already created by the Teacher in Step 1, to work with. He or she can then contribute to the chosen Demo Student's work via his or her local keyboard and mouse/pen. Of course, the same limit of 10 simultaneous student connections imposed by the Windows Vista Operating System still applied as before.

In this second "collaborative" mode, the Teacher Desktop PC acted more like a "switch-board" switching in and out the Demo Students' desktops while maintaining its "host" capability for Contributing Students' PCs as in the first "collaborative" mode.

This new instructional system was designed to make the Teacher Desktop PC become a "common learning space" where any student can put up (or withdraw) their works there, when and if they want to do it, allowing much more natural behaviors. One benefit was that the Teacher could compare several student works "side-by-side", although up to the 10-connections limit imposed by the Windows Operating System and as much as the resolution of the Teacher PC Desktop allowed. Here the desktop's resolution used was limited by the multimedia recorder tool Camtasia Studio to 1024x768 to keep the 75-minute lecture recordings at reasonable file sizes. The truth is that 10 concurrent students were really more than any single instructor could handle at any one time. Another benefit was that each student could annotate the other student's work being "shown", resulting in a more flexible "collaborative" tool than the standard (and more lengthy) procedure of using the "Show Leader" or "Exhibit" tools as originally recommended by the software manufacturer NetSupport Limited [2]. Each student could also create their own notes using the Pen Tablet and the Windows Snipping Tool from Vista and save them in a variety of file formats (HTML, JPG, etc…).

B. Other Implementation Details

We preferred to use USB-Port Pen Tablets over Tablet PCs because they were cheaper to buy and maintain and allowed us to use our existing desktop PCs while the mobility features of Tablet PCs were not needed in our case as we were bound to the classroom space. We also had to upgrade to Windows Vista as it is the only OS that would allow full digital ink capabilities for Pen Tablets.

At first, we planned to use personal microphones on all student PCs for audio communications as an "undocumented" feature was uncovered during our experimentations with NSM V.9 whereas we could achieve voice conferencing capability for "free" at the Teacher Desktop PC. However V.9 did not work with Windows Vista and when we updated to V.10 for Vista compatibility, we had found that the Audio tool no longer worked properly (NetSupport Limited acknowledged this problem but they had not provided any solution up to now). Thus our next plan is to drop omni-directional microphones from the classroom ceiling and use analog mixers to bring all audio inputs into the Teacher Desktop PC audio input for Camtasia recordings. Currently, the instructor has to repeat the student's questions in order to have them recorded in Camtasia Studio audibly.

For a demonstration of this system, the reader can access narrated recordings of a demo session from 3 points of view: Teacher Desktop PC, Teacher Tablet PC and Student PC at http://www.engr.uga.edu/people/thai/BAE310-F07.htm.

III. Preliminary Assessments

So far in the current Fall 07 semester, all hardware and software functioned as designed. Starting in August 16, 2007, we had been using this system for a course on Modeling of Discrete-Event and Continuous-Time Systems with 10 students.

On 9/25/07, 7 out 10 students answered a short survey about various aspects of the course so far. Students were asked to respond to the following 8 questions using a 6-point Likert scale where "StD" meant "Strongly Disagree", "D" meant "Disagree", "SlD" meant slightly disagree, "SlA" meant "Slightly Agree", "A" meant "Agree" and "StA" meant "Strongly Agree":

1. In-class course materials delivery methods were effective.
2. I understood the materials presented during in-class lectures.
3. Materials presented via PowerPoint slides were effective.
4. The Pen Tablet was an effective tool to take notes in class.
5. Sample models presented via Arena software were effective.
6. Recorded lectures were easily accessible.
7. I felt comfortable going through recorded lectures.
8. I understood the materials presented in recorded lectures.

Student responses are shown in Table 1 (please note that only 7 out 10 students returned the survey). Although results from Question 1 showed that in-class delivery methods were mostly effective, results for Questions 2 and 8 clearly showed the benefit of the availability of the recorded lectures with Question 8 scoring higher than Question 2. The author has seen this pattern repeated in his other courses on Introductory Java Programming [6]. The interesting fact to point out was that the recorded lectures were just straight unedited recordings of the classroom activities, but somehow the students felt that they understood the materials in the recorded versions better, perhaps because it would be the 2nd time that they would see and hear the materials, and perhaps the "timing" of the review was more conducive to their learning processes as they were "ready" to deal with the materials, and also they could pick out only the needed information as many times as needed, all of which not possible to achieve during the actual lectures.

mmeybodi@aut.ac.ir

Table 1. In-class & Off-Line materials effectiveness survey results.

Question #	"StD"	"SlD"	"D"	"SlA"	"A"	"StA"
1				3	3	1
2		1		1	4	1
3		1	2	2	2	
4	3	3	1			
5				1	1	5
6				1	3	3
7				2	3	2
8				1	3	3

The effectiveness of the PowerPoint slides used was mixed (Question 3) and students definitely did not like to use the Pen Tablets (Question 4). One student actually declared that the Pen Tablet was "alien" technology. This resistance may be due to the fact that all students were using the Pen Tablets and the Windows Vista Snipping Tool for the very first time. Other students also expressed unfamiliarity with the operation of Windows Vista which may contribute to this resistance. Reviewing the Tablet PC recordings of the in-class "scanning" of students desktops showed that some were looking at the PDF version of the PowerPoint slides as posted on the UGA Course Management System web site, while others were going through the sample Arena models themselves, or just were doing other tasks unrelated to the course. It also must be recognized that the software applications needed in our course, Arena and Stella, were not designed to exploit the full capabilities of the Pen Tablet as they were created with keyboard and mouse in mind. However from the point of view of the instructor, the Pen Tablet and the Windows Snipping Tool were indispensable as their combination allowed the teacher to "snip out" a section of the model being presented into a separate window where it served as the starting point for more detailed discussions with the students (using the pen) so as to increase comprehension of the issues involved.

Results for Question 5 clearly showed that this could be an effective pedagogical approach to teach Discrete-Event modeling concepts by using worked-out sample models facilitated by our computerized instructional system. Results for Questions 6 through 8 showed that our UGA Course Management System was also quite useful and effective.

On 9/20/07, the first test was given with the following results based on 10: 6, 6.8, 7.5, 7.5, 8.3, 8.5, 9, 9, 9.3, and 10 for an overall average of 8.19 and an obvious bi-modal distribution. On 10/11/07, the second test was given with the following results based on 10: 3, 4.5, 5, 5, 6.5, 7, 7, 7, 8.3, and 9 for an overall average of 6.23 (a drop of 2 points) and still showing an obvious bi-modal distribution.

Using the Tracking tool from the Blackboard Vista CMS, we computed the amounts of time spent by students perusing different types of files posted there and compared these values with the corresponding student test grades and other observations in class so as to detect any correlations and perhaps to discern possible learning styles for each student. There were 3 types of files available to students: Type 1 was PDFs containing PowerPoint slides and other instructor-prepared class notes, Type 2 was narrated classroom lectures or specially-made tutorials for specific purposes, and Type 3 was actual Arena or Stella model files. These time results (in minutes) are shown in Table 2 for the top half of the class and Table 3 for the second half.

Table 2. Time periods (minutes) spent on various file types for class top half and corresponding test grades.

Time Period	File Type	Student 1	Student 2	Student 3	Student 4	Student 5
8-16 to 9-21	**All**	543	82	27	75	30
	1	108	54	8	41	27
	2	3	2	***17***	***34***	0
	3	432	26	2	0	3
Test 1		**10**	**9.3**	**7.5**	**9**	**9**
9-22 to 10-11	**All**	88	28	362	23	90
	1	0	4	187	2	1
	2	0	0	***115***	0	***45***
	3	88	24	60	21	44
Test 2		**9**	**8.3**	**7**	**7**	**7**
10-12 to 11-16	**All**	80	90	75	36	41
	1	79	40	12	30	35
	2	1	0	***63***	0	1
	3	0	50	0	6	5

Table 3. Time periods (minutes) spent on various file types for class second half and corresponding test grades.

Time Period	File Type	Student 6	Student 7	Student 8	Student 9	Student 10
8-16 to 9-21	**All**	95	158	41	160	10
	1	144	139	12	52	4
	2	***51***	***11***	1	***16***	6
	3	0	8	28	92	0
Test 1		**6**	**6.8**	**8.5**	**8.3**	**7.5**
9-22 to 10-11	**All**	49	41	45	75	20
	1	20	0	0	0	0
	2	11	***10***	0	***17***	1
	3	18	31	45	58	19
Test 2		**6.5**	**5**	**5**	**4.5**	**3**
10-12 to 11-16	**All**	33	99	43	78	90
	1	32	71	33	38	58
	2	1	***27***	9	***37***	***11***
	3	0	1	1	3	21

Tables 2 & 3 showed only Students 3, 7 and 9 reviewed the recorded class lectures regularly, while the rest were occasional reviewers only. It is interesting to contrast these results to the ones from Table 1 where the students mostly agreed that the recorded classroom lectures constituted a useful resource, however they did not use it regularly. The top student (1) practically did not use the recorded lectures at all, but preferred to use the PDFs and model files, however this student was active in class, but did not take much class notes, so it seemed that this student must have very good visual and auditory memories, and seemed to learn more by reviewing text notes and practicing with actual simulation models. Overall there seemed to be no trends between the two halves

mmeybodi@aut.ac.ir

of the class regarding total times spent reviewing materials posted on Blackboard Vista. However individually, students 2, 7, 9 and 10 definitely switched gear after Test 2.

IV. Conclusions

Recent multimedia and computer technologies allowed the design of a classroom that exhibited both "teacher-centric" and "E-collaboration" characteristics by using the NetSupport Manager (NSM) suite. Although NSM was a "teacher-centric" design, it's "Tutor" and "Control" tools were creatively recombined to provide both aspects. A more affordable access to pen technologies was possible by using existing desktop PCs equipped with Pen Tablets instead of the more expensive Tablet PCs. However so far students had shown resistance to using this technology, thus in the future we plan to spend more time at the beginning of the course for student training in using Pen Tablets and related note-taking software in Windows Vista. Recently, we had performed a limited experiment whereas one student PC was equipped with Dual Graphics displays so that the student could use ONE display for his or her "PERSONAL WORKSPACE" while the SECOND display was used for the teacher to send over the materials shown on the Teacher Desktop in the Teacher-Centric Mode, or to be used by the student to remotely share into the Teacher Desktop when the class was in Collaborative Mode. This approach received good acceptance from the testing student, thus equipment are being purchased so that Dual Graphics displays can be deployed for all student PCs in Spring 08 semester.

Potential beneficiaries of this type of facility are teachers and students in courses where instructor and students can access their own computers allowing the following features:

1. Courses needing network access to remotely located lab equipment during lectures or emphasizing the development of problem-solving skills in students that can represented with graphics and hand-written annotations.
2. Increased student interests and interactions in classroom lectures are expected and students are empowered in generating richer and personalized multimedia notes and sharing their solutions with peers as lectures and labs are merged seamlessly.
3. 24/7 access to recorded classroom activities via the web is enabled for students to do reviews at their convenience.
4. Teachers and administrators can also use classroom recordings to evaluate instructor's effectiveness as well as to understand student behavioral and learning patterns during class.

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mmeybodi@aut.ac.ir

Can Multicore Processing Learn from Arithmetic Concepts?

Conrad Mueller
The School of Computer Science
University of the Witwatersrand, South Africa
cmueller@acm.org

Abstract- **Many see multicore processors as the way to solve the limitations of the uniprocessor. These architectures are not without problems. We argue that to address these problems, architectures needs to move away from an instruction-based model. The paper looks at how arithmetic and natural deduction can form the basis of a computational model that can be used to implement multicore architectures.**

I Introduction

In almost every ACM TechNews headlines there is a clip relating to how to take the development of architectures forward. The memory wall is coming ever closer as is well illustrated in the paper by Wulf and McKee[1]. There is only so much that one can speed up the clock and chip[2], hence researchers and manufacturers are looking for other solutions to achieve better CPU performance like multicore or manycore chips[3, 4, 5]. However there is the need to address both the memory wall and CPU performance. For decades parallel computing has shown promise but the uniprocessor has continued to dominate[6]. Even though Backus[7] in the 1970s raised the problem of the von Neumann bottleneck, earlier lack of success with dataflow architectures appears to have stalled research along these lines. As the limitations of the uniprocessor have become more pressing, we see new interest in exploring other options with renewed interest in dataflow. There have been reported successes with hybrid dataflow architectures[4]. However they are still based on the von Neumann instruction based model. Using this instruction based model of computing on multicore or manycore is complex as it needs to take into account the particular configuration of the architecture and programming is notoriously difficult[6]. This paper explores the approach suggested by the Berkley group that there needs to be a synergy between the programming model and the architecture to enable parallel computing to take off. They suggest a number of properties such computational models should ideally have. We focus on breaking away from the instruction-based model as a way to address the following three critical areas: improving parallelism, reducing the data bottleneck and simplifying parallel programming.

In the 1950s, Kleene[8] argued that a program is limited to a finite number of variables due to the finite number of addresses. This thinking resulted in the computing concept of a variable that can take on a number of different values and that programs use instructions to manipulate the data stored in variables. Functional programming attempted to go back to the more mathematical concept of a variable. While functional programming does not limit the programmer to a finite number of variables, the programmer is limited to a finite number of identifiers to reference variables. The only way a programmer can get around the finite number of variables is to use recursion. This restricts the way in which these variables can be accessed as they are only available within the scope of the function call. Our argument is that even though a program has infinitely many variables available to the programmer, a programmer is forced to use the same identifier to access infinitely many variables and hence, just like the imperative programming approach, is forced to take into account which stage or level of recursion a program is at, in order to interpret the meaning of that identifier. We argue there should be unlimited variables that can be referenced uniquely by a programmer. Such a model enables us to achieve our three objectives of improving parallelism, reducing the data bottleneck and simplifying parallel programming. Associated with each data element is unique semantic information that allows the element to determine how it is processed. These elements can be processed by any processor and in any order. The degree of parallelism is only restricted by the data dependencies that determine the order in which the data elements are created. The bottleneck is reduced in that these data elements do not need to be stored in high speed memory and are fed to the processors. Programming is simplified in that the programmer does not manage the parallelism.

The most interesting aspect of this model is that it is based on what humankind has been doing for centuries – arithmetic. Those steeped in programming struggle to understand this model as they try to interpret it in terms of the von Neumann concepts. For example, in arithmetic we are able to refer to infinitely many variables using indices. The identifier and the index are part of the reference and not two distinct variables as in current programming paradigms. Arithmetic does not have control structures like loops and conditional statements. Arithmetic does not have operational semantics but describes relationships between variables. In our proposed model, one cannot reason about a program as a sequence of steps, which makes it difficult to understand for those who have already developed this way of thinking. Our objective in this paper is to focus on the important concepts. To do this we have simplified the explanation by leaving out details and restricting aspects like

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 79–85.
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mmeybodi@aut.ac.ir

showing how the model works with one index rather than any number.

II Computation Model

Our model of computation is different from the existing von Neumann model. While it has aspects of the data flow model, it requires a completely different way of thinking about computation. As most will find the model foreign and difficult to follow, we introduce the concepts using every day analogies. The approach is a move away from an instruction based, traditional view of doing computation. As with declarative and functional programming, programs are expressed as relationships. However the way in which these relationships are used in the computation is different.

The first concept that we wish to look at is that of retaining semantic information with the value. In current models, a value is stored in an address. The meaning of this value is determined by the instructions. In our model, neither the address nor the program determines the meaning of a value. Instead we have a tuple consisting of semantic information and a value. The semantic information is used to determine how the value is used in the computation. We use mail as an example to illustrate this concept. In our analogy the envelope with the name and address is the semantic information and the contents of the letter the value. Where to deliver the letter is determined by the envelope and not by the person delivering the letter or where the letter is stored. The advantages are that: any postman can use the information on the envelope to process the letter, processing the letter does not rely on a postman remembering where to deliver the letter as all the information is on the letter and it does not rely on an indirect reference to determine where to deliver the letter to. In a sense the letter is self contained and does not require anything like a memory address or a program to determine its meaning.

Like with the letter example, we associate the semantic information with a value. The semantic information is the variable name for example "length". The value represents an element in the set of possible lengths – for example 5. We refer to the tuple (length, 5) as an element. The semantic information "length" is used to determine which relationship(s) this element applies to in the same way that the name and address on an envelope enables the postal service to determine where to deliver a letter.

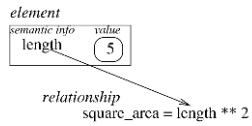


Figure 1. Establishing link with relationship

The second concept we need to illustrate is that having the semantic information together with the value enables the process to be driven by the data rather than instructions. To illustrate this aspect we use the analogy of doing a simple jigsaw puzzle. The image on the piece is analogous to the semantic information and the piece the value. The person constructing the puzzle can pick up one piece at a time, use the picture to find the relationship the piece has to the rest of the pieces and place the piece in the appropriate place. This example illustrates how data, in this case puzzle pieces, can drive the process of building the puzzle. Also the example illustrates that a number of people can simultaneously work on the puzzle. The order in which the puzzle is constructed depends on the order in which the pieces are picked up.

As with the puzzle, our model of computation processes the elements by looking at their relationships with other elements. For example a relationship may be expressed as "square_area = length ** 2". Given the element (length, 5), we can use the semantic information "length" to establish that this element applies to the relationship "square_area = length ** 2". This relationship enables us to determine the element (square_area, 25). This newly defined element can now be processed in the same way as the element (length, 5). The figure below illustrates how the semantic information "length" is used to identify that the element (length, 5) applies to the relationship "square_area = length ** 2" and that given the value and the relationship, one can compute a new element (square_area, 5**2) or (square_area, 25).

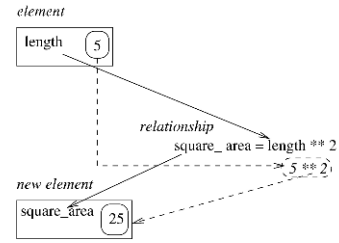


Figure 2. Creating a new element

Another important concept is how synchronization can be achieved using the relationships together with semantic information. To illustrate this concept, we use the example of a squash tournament in which players are paired and allocated a court. In this example we have a list of courts and the pairs of players scheduled on that court. The players consult the list to see on which court they are playing. If the other player is at the court, they can start their game. If the other player is not there, they wait until the other player arrives. Here the court name or number is used to synchronize the two players to enable them to start their match. Given the relationship "Court 1 is for players: Jones and Smith", enables Jones and Smith to synchronize using Court 1 as Court 1 defines a relationship between Jones and Smith. Many computations of values are defined in terms of a number of other values. These values need to be synchronized before the computation can take place.

As with current compiler techniques, we can break up a complex computation into a series of operations. Hence an expression like "volume = height * length * breadth" can be broken into "area = length * breadth" and "volume = height * area". If we now look at a relationship like "area = length * breadth", the elements of length and breadth need to be synchronized before the element area can be computed. We can think of a length element as one of the players – say Jones and a breadth element as the other – Smith. If the breadth element

mmeybodi@aut.ac.ir

is processed first, we can use the relationship "area = length * breadth" to determine that breadth is used to calculate area in the same way that the allocation of courts can be used to determine which court Smith needs to play on. We associate the name "area" with the element breadth in the same way as "Smith" is associated with the Court 1. The computation can only processed if the other element associated with "area" is available. Since it is not, the process needs to wait until the other element arrives – just as Smith has to wait at Court 1 for Jones. At some later stage, the length element will be processed and it will be associated with "area". On checking, the process will find the other element associated with "area" is already available. The process can now compute the new element area in the same way that Smith and Jones can now start their squash match. Figure 3 below illustrates this process.

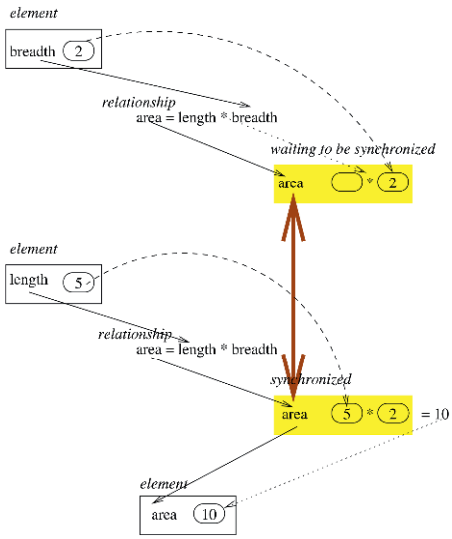


Figure 3. Synchronization

We have so far illustrated how a single individual element gets created. The next step is to look at computations involving multiple relationships. We go back to the example of calculating the volume.

area = length * breadth

volume = area * breadth

Assuming the elements (length, 8), (height, 6) and (breadth, 3) come into existence in that order. The computation proceeds as in figure 4.

What we have discussed so far allows for computations to be expressed for a finite number of elements. However many computations involve any number of values to be computed. The question is how can this be achieved? Let us look at the relationship "area = length**2". This defines the relationship between length and area. But the same relationship might hold for a whole lot of different rooms. We can express this relationship as "$area_{room}$ = $length_{room}$**2" where "room" specifies which room it is. So this now describes relationships between $length_1$ and $area_1$, $length_2$ and $area_2$, etc.... The semantic information contained in each element now consists of two parts. For example consider the element ($length_{25}$, 7). This element has semantic information *length* and *25*. This semantic information and the relationship "$area_{room}$ = $length_{room}$**2" is used to determine the specific relationship between $length_{25}$ and $area_{25}$ by substituting 25 for "room" in the relationship. This gives the relationship "$area_{25}$= $length_{25}$**2". Figure 5 illustrates how this is done.

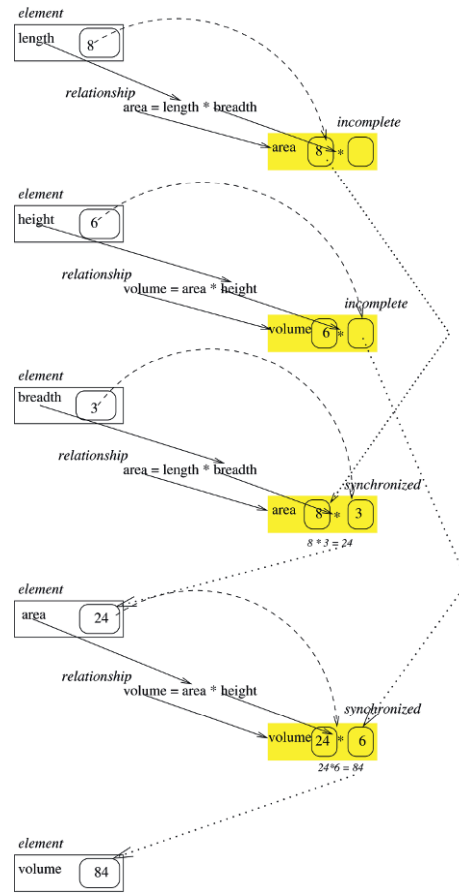


Figure 4.. Computation involving two relationships.

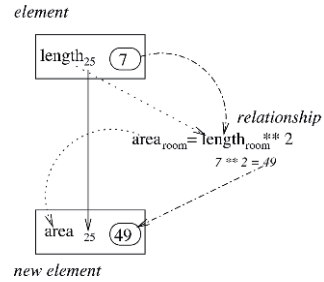


Figure 5. Using indices

mmeybodi@aut.ac.ir

Next we show how to do the first few steps of addition for the following program that sums a lists of numbers n_is.

$$\text{sum}_0 = 0$$
$$\text{sum}_{i+1} = \text{sum}_i + \text{n}_i$$

In this case one not only computes a sum, but also has to increment the index. Because the index is part of the element's semantic information and not a separate element, we introduce the notion of an 'index operation' to increment the index part of the element. The compilation step would be required to break the second line into two steps where the first computes the sum and the second increments the index. The distinction between these two operations will become clear later.

$$\text{temp}_i = \text{sum}_i + \text{n}_i$$
$$\text{sum}_{i+1} = \text{temp}_i$$

In figure 6, we show how this simple program is evaluated for the elements (n_0, 5) and (n_1, 7).

A concept that is important to get across is that of elements coming into existence, getting processed and then discarded. We wish to show the transitory nature of elements that are used in intermediate steps of computing a result. The process of life is used as an analogy. Male and female organisms mate to create new offspring. These new offspring in turn mate and create a new generation of offspring. The organisms die after they have produced their offspring. Some organisms produce no offspring and some produce a number of offspring. In the same way elements are used to create new elements. Once they have been applied to all the relevant relationships they can be discarded. Some elements will apply to a number of relationships creating a number of new elements. Others will apply to none or the result of applying them to a relationship will not result in a new element being created. The following diagram illustrates an element's life cycle. In many ways this is similar to the way in which arithmetic is done. Values are used to calculate other values and once they have been used they are discarded. Arithmetic expressions are used to decide how to use the values in computing new values.

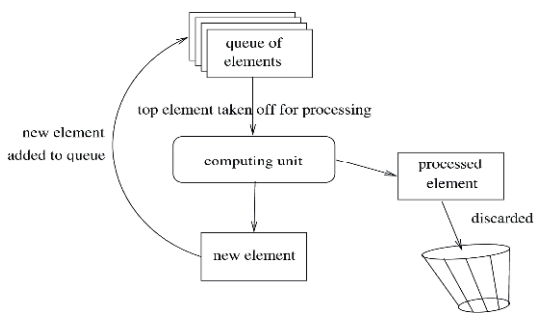


Figure 7. Life cycle of elements

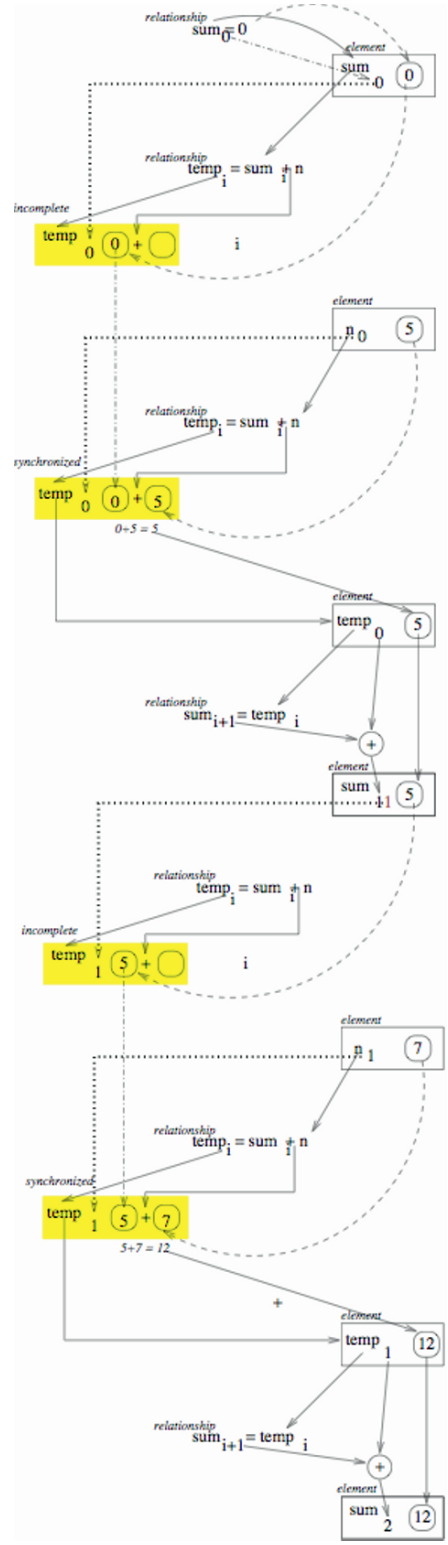


Figure 6. A simple summation example

mmeybodi@aut.ac.ir

The computing unit consists of three components: a *mapping* unit that establishes the relationships that apply to the element being processed; a *synch* unit that synchronizes values required to compute a new element and an *eval* unit that computes the new elements.

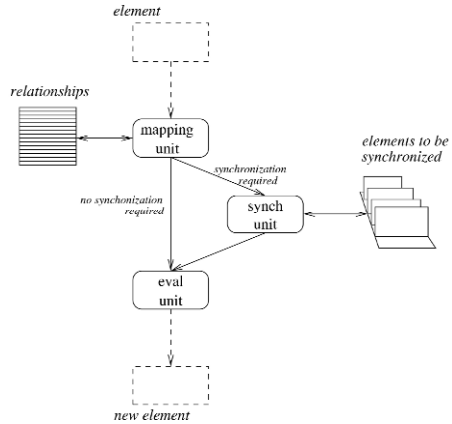


Figure 8. Computing unit

The function of the mapping unit is to identify the relationship(s) an element applies to and for each create an incomplete element that contains the information from the relationship and element needed to compute the new element. The incomplete element contains the identifier, operation and in some cases a constant from the relationship and the index and value from the element as shown in figures 9 and 10. In the case a value is missing for a binary operation the incomplete element is passed onto the syn unit whose function is to synchronize the two incomplete elements required to compute the new element. Otherwise, the incomplete element is passed straight to the eval unit whose function is to apply the operation to the values and create a new element.

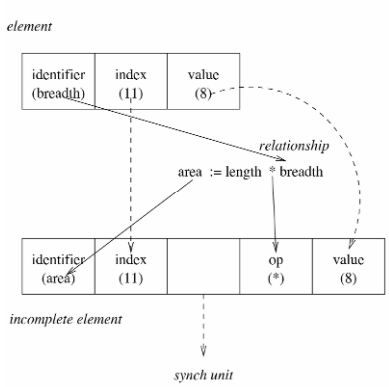


Figure 9.Creatation of incomplete element (synchronization)

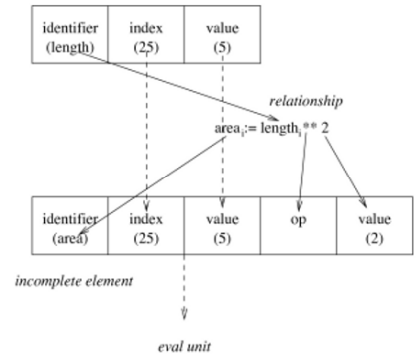


Figure 10.Creatation of incomplete element (no synchronization)

The synch unit checks if there is an incomplete element with the same identifier and index. If there are the two incomplete elements are combined and passed on to the eval unit. Alternatively the incomplete element is stored (in a hash table) until it can be synchronized. The eval unit accepts incomplete elements from both the mapping and synch units. It applies the operation to the values in the incomplete element to create a new element. The new element consists of the identifier of the incomplete element, an index that is the index of the incomplete element and the calculated value. Some operations involve computing a new index in which case the new element's index will be the result of computation.

Programming turns out to be little more than a set of basic arithmetic expressions. The expressions are in the form of relationships defining variables in terms of others, e.g.

$$\text{area} = \text{breadth} * \text{length}$$
$$\text{sum}_{i+1} = \text{sum}_i + \text{number}_i$$

An important aspect is that the expressions define a variable. To stress this and to help with syntax recognition, we use a define symbol, i.e. ":=". Expressions used in defining variables are made up of variables, constants, and operations as typically used in arithmetic expressions. Variables consist of an identifier and any number of index expressions.

Programming is the task of finding the relationships that exist between values computed. Let us take a reasonably complex algorithm – an insertion sort. The sort consists of a number of passes. In each pass the next unsorted element is inserted. All the elements less than or equal to the unsorted element are copied into the same position in the sort, i.e.

$$p_{i+1,j} := p_{i,j} \textbf{ if } p_{i,j} <= u_{i+1}$$

where $p_{i,j}$ is the element in the i^{th} pass and j^{th} position in the sorted list and u_i is the i^{th} element in the unsorted list. Similarly the elements greater than the unsorted element need to be copied into the next position to make way to insert the next unsorted element, i.e.

$$p_{i+1,j+1} := p_{i,j} \textbf{ if } p_{i,j+1} > u_{i+1}$$

mmeybodi@aut.ac.ir

Now the unsorted element needs to be placed into the correct position. This element needs to have the following property

$$p_{i,j+1} > u_{i+1} >= p_{i,j}$$

This can be expressed as follows:

$$p_{i+1,\,j} := u_i \ \textbf{if}\ p_{i,j+1} > u_{i+1} >= p_{i,j}$$

Finally we need to deal with the boundary conditions. The first task is to define the first pass,

$$p_{0,0} := u_0$$

And then the cases when u_i is less than the first element $p_{i,0}$ or larger then the last element $p_{i,i}$. These cases can be expressed as:

$$p_{i+1,0} := u_i \ if\ p_{i,0} > u_{i+1}$$
$$p_{i+1,i+1} := u_i \ if\ p_{i,i} <= u_{i+1}$$

Putting it all together we get the follow program:

$$p_{0,0} := u_0$$
$$p_{i+1,j} := p_{i,j} \ \textbf{if}\ p_{i,j} <= u_{i+1}$$
$$p_{i+1,j+1} := p_{i,j} \ \textbf{if}\ p_{i,j+1} > u_{i+1}$$
$$p_{i+1,\,j} := u_i \ \textbf{if}\ p_{i,j+1} > u_{i+1} >= p_{i,j}$$
$$p_{i+1,0} := u_i \ \textbf{if}\ p_{i,0} > u_{i+1}$$
$$p_{i+1,i+1} := u_i \ \textbf{if}\ p_{i,i} <= u_{i+1}$$

III Conclusion

We have shown how programming can be expressed and evaluated using the basic principles of arithmetic. Programs are expressed in terms of relationships rather than instructions for manipulating data. Unlike an imperative programming statement, the semantics of the arithmetic relationships are static and do not change depending on the state of the program or the level of recursion the program is in. These relationships can be defined for infinitely many variables using indices. These indices are part of the variable and not variables in their own right. Computation is expressed as defining variables in terms of others. It is this property that enables computation to be determined by the data elements themselves to achieve the three objectives we have focused on in this paper: improving parallelism, addressing the memory wall and simplifying programming.

The principles of arithmetic allow a distinction to be made between a variable and an actual data element. Thus a data element can have meaning independently of the program description and the state of the program. Data elements can thus drive the computation as their semantic information can determine how they are processed. This allows for any number of unprocessed elements to be processed in parallel. The computation model is one that enables a fine grain of parallelism (at the atomic level of a single operation) that is only restricted by data dependencies. We argue that this model facilitates more effective exploitation of parallelism.

Maintaining the semantic information with the data enables a radically different approach to how data is managed. The data elements drive the process rather than instructions manipulating data. The data is fed through the system rather than having to be stored and accessed from memory. The unprocessed elements waiting to be processed do not need to occupy expensive high-speed cache. All processed elements are discarded. Only elements waiting to be synchronized are kept in memory. No memory is allocated for data yet to be computed or data that will not be used before the cache block is paged out. The retaining of the semantic information with the data element has another major benefit in that there is no need for context switching as the state is contained in the data elements. Thus the volume of data having to pass through the memory bottleneck is significantly reduced with less data having to be accessed from memory and reduced caching or memory faults. We argue that this will make a significant impact on addressing the problems with the memory wall.

Finally we look at how the model makes programming simpler especially that of expressing parallel programs. The burden of managing memory is removed from the programmer using this model. A program only expresses relationships between variables and not how they are stored. A programmer does not need to ensure that the sequence of execution will result in the correct values being available in variables when computing a new value. The meaning of a relationship holds irrespective of the stage in the computation – unlike a statement in an imperative program that depends on the current state. Thus even for programs designed for uniprocessors, there are significant benefits. The bigger benefit is with parallel programming. The programmer does not need to manage the processes and how they are allocated to processors. The design of the program does not need to take into account the configuration of the processors. The only task different when writing a program to exploit parallelism is designing the algorithm such that the data dependencies are reduced – a task that is at the heart of parallel programming. The model reduces the complexity of programming significantly making it more accessible.

Multicore and/or manycore processors are seen as the solution to addressing the limits of the uniprocessor. We argued that three aspects needed to be addressed for parallelism to provide the answer: to improve the degree of parallelism, to address the memory wall and to find easier ways to express programs to run in the parallel environment. We have shown how using the concepts of arithmetic can address these three aspects. The two concepts of arithmetic critical to this model are that relationships can be expressed between unlimited numbers of variables and the distinction between a variable that represents all possible elements of a set and a value that represents a particular element in the set. These two concepts are used to move away from a memory-oriented model of computation to one of processing data elements. Being able to process data elements independently allows elements to be processed in parallel. The move away from a memory-oriented approach helps eliminate the memory bottleneck. Not having to manage memory or parallelism reduces the complexity of programming.

The real proof of the model would be in an implementation. A prototype compiler and interpreter have been implemented to

mmeybodi@aut.ac.ir

test the ideas. This prototype tests the ideas expressed here as well as user defined operations, variables with any number of indices and aspects of concurrency. Some elementary exploration has been done into looking at how to implement the hardware. However the task of implementing a complete system is beyond the capabilities of a single researcher as highlighted by the Berkley researchers[6].

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mmeybodi@aut.ac.ir

Come Play

Craig Caulfield
S. P. Maj

School of Computer and Information Science
Edith Cowan University
Perth, Western Australia

***Abstract*- Games have been used as learning tools in many different business, military and social environments, but appear to be under-represented in a critical modern situation—software engineering: the systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of software. Despite the name, software engineering may not enjoy the same standing as the more established engineering professions. Anecdotal evidence suggests that an urgent software crisis exists (a gap between expectations of software and the product and performance actually delivered) and has been growing since the 1960s. While quantitative data proving the existence of a software crisis is thin, it might be conceded that software engineering has room for improvement. This paper presents a case that the use of games as a research tool in software engineering needs to be more fully explored and an opportunity exists to use games to tackle some of the current issues in the field.**

I. INTRODUCTION

In the science fiction novel *Ender's Game* [1], alien attacks on the Earth prompt the world government to begin training children as future military commanders by setting them to play continuous tactical and strategic computer war games. Amongst the current crop, one player stands out, Ender Wiggin— he wins every time by learning and adapting to the ever-more ridiculous challenges his teachers confront him with. For his success, Ender is selected to lead a small team of children in a complex computer battle simulation of a final confrontation with the aliens; a confrontation that ends when the aliens' home planet is destroyed. Only later is it revealed that Ender and his fellow players have been commanding real weapons, and the alien treat is suddenly no more.

As Ender and his friends realise, games can be more than play and have the potential to show us things we don't already know. These two facets of games raise the possibility that games can be considered as valid research tools.

Some definitions are first in order as the word 'game' is often used carelessly and interchangeably with model and simulation [2]. To start, a model can be described as "a miniature representation of a complex reality. A model reflects certain selected characteristics of the system it stands for. A model is useful to the extent that it portrays accurately those characteristics that happen to be of interest at the moment" [3].

A model is almost guaranteed to be incomplete because it is an abstraction of reality; the exact components of reality included in the model will depend on what the user is trying to explore. Even so, a model "saves us from a certain self-deception. Forced into the open, our ideas may flutter helplessly; but at least we can see what bloodless creatures they are. As inquiry proceeds, theories must be brought out into the open sooner or later; the model simply makes it sooner" [4].

Meanwhile, a simulation is a special kind of model that exhibits processes in some way like the system is represents, and that shows how these processes change from state A to state B, between two points in time [5].

Finally, to play a game, "is to engage in activity directed towards bringing about a specific state of affairs, using only means permitted by specific rules, where the means permitted by the rules are more limited in scope than they would be in the absence of the rules and where the sole reason for accepting such limitation is to make possible such activity" [6].

Therefore, as used here, a model is a convenient representation (in words, numbers, or other symbols) of some real-world, socio-economic or socio-technical system; a simulation is dynamic, operational model through which changes over time are revealed; and a game is a simulation that is purposefully run, wholly or partly determined by players' decisions, within some predetermined circumstances.

Serious games, that is, games beyond simple amusement, draw their intellectual integrity from a number of sources including educational theory [7-10], operations research [11, 12], small-group behaviour research [13, 14], war-gaming, decision sciences, and systems engineering [15]. The aim of this paper is to show that games have a maturity, breadth, substance, and a role in research beyond the unprepossessing name.

II. THE VALUE OF GAMES AS RESEARCH TOOLS

To a common extent, games have been found to be more expensive and administratively demanding to develop and use than some other forms of instruction or research [16-21]. Still, there are some offsetting advantages.

For example, it has been noted that the human capacity to understand the implications of our mental models and to accurately trace through even a smaller number of causal relationships is fairly limited [22, 23]. Yet, a game is a visible and physical representation of a problem space; a captured mental model. As such, they are places to trial new ideas and to experiment with established theories [24, 25]; to replay these theories as many times as needed; places where time and space can be contracted or expanded [15];

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 86–91.
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mmeybodi@aut.ac.ir

places where it is acceptable just to try different things and where more might be learned from failure than success [26].

Even so, there are some dangers to be heeded when using games. Games are just… games, and as such are just one representation of how the world works. Therefore, "it is potentially dangerous to have players leave the gaming environment with the belief that the strategies that were effectively employed in playing the game are directly transferable to the real world" [19]. Participants should ideally be provided with more information than just the game to help them wisely discriminate between what may or may not work outside the game itself [27].

Further, the favoured contemporary medium for games, computers, make it possible to implement games of incredible richness. Such games might be able to accommodate elements of time pressure, decision-making, analysis and negotiation skills, all presented through a multi-media interface. In this situation, participants might also tend to play the game to win, as they might an arcade game, rather than to learn [18, 28]. Alternatively, the richness or over-design of the game may overwhelm or discourage other participants [17, 27]. Therefore, there needs to be an appropriate emphasis on technology and a balance of game elements at each stage [29].

The balance of a ledger of pros and cons of games given so far may still not be enough to convince some of the value of games. However, such sceptics may be demanding of games a certitude that even more mature tools and fields cannot demonstrate:

"Laboratory tests, in situ tests, and the analysis of natural analogs are all forms of model confirmation. But no matter how many confirming observations we have, any conclusion drawn from them is still an example of the fallacy of confirming the consequent. Therefore, no general empirical proposition about the natural world can ever be certain. No matter how much data we have, there will always be the possibility that more than one theory can explain the available observations" [30].

Moreover, how we understand a tool's relationship to the real world can have a bearing on how we perceive its utility:

"A model, like a novel, may resonate with nature, but it is not a "real" thing. Like a novel, a model may be convincing— it may "ring true" if it is consistent with our experience of the natural world. But just as we may wonder how much the characters in a novel are drawn from real life and how much is artifice, we might ask the same of a model: How much is based on observation and measurement of accessible phenomena how much is convenience? Fundamentally, the reason for modelling is a lack of full access, either in time or space, to the phenomena of interest" [30].

In contrast, others [15, 31] believe that this traditional test of model, simulation, or game validity— isomorphism to the reference system— is both inappropriate and inadequate. A more fruitful way to judge validity is in terms of its usefulness in reaching particular goals:

"'Usefulness' does not provide an objective standard for measurement, but allows each scholar to answer the validity question for himself within the context of his own experiences and purposes. While such an individual standard raises the spectre of non-scientific, subjective evaluation, it should be borne in mind that the 'objective truth' implied in asking for isomorphism is also a phantom. Our knowledge of the 'objective' world is too limited, our measures and our senses too fallible, our theories too uncertain and contradictory, and our data too ambiguous to justify and claims to real objectivity, no matter what means we might use to determine validity" [15].

Therefore, the value of a game depends on its stated objectives, which in turn depends on its purpose [19, 32].

III. AN EXAMPLE: THE BEER GAME

To demonstrate the utility of games as a research tool, a session of the Beer Game was held amongst teams of post graduate students from Edith Cowan University. The Beer Game is a simulation of a four-point distribution chain, originally developed at MIT and now used widely as a management educational tool in a variety of academic and commercial settings [33-36].

Each team of players takes one of the roles in the distribution chain— either retailer, wholesaler, distributor, or factory. The retailer interacts with a fictitious customer who buys cases of beer. The retailer draws cards from a deck at the beginning of each time period to find the customer demand and then orders stock from the wholesaler accordingly to maintain their inventory. To simplify things, there are no lost sales: if there is insufficient stock on hand, the retailer creates a backlog and fills the order when replenishment stock arrives.

The wholesaler receives downstream orders from the retailer and places upstream orders with the distributor. Again there are no lost sales and a backlog is created if necessary and filled when stocks become available.

The distributor interacts with the wholesaler and the factory in a similar way.

The factory is only concerned with production scheduling and since raw materials are always made available, the factory will produce as much beer as asked for.

To simulate the realities of the market place, there are shipping and order processing delays between the four points of the distribution chain. This means that orders will not be filled immediately and each point in the distribution chain will need to factor this delay into the ordering decisions.

The central theme of the game is inventory management— the price of the beer isn't important. Since the inventory carrying cost is set at $0.50 per case, per week, and the out-of-stock cost is $1.00 per case, per week, the aim is to maintain the minimum level of inventory to meet demand, taking care not to hold too much stock, while also ensuring that a backlog doesn't build up. To simulate market conditions, none of the teams were allowed to confer with other teams. In the real world, the retailer for example,

mmeybodi@aut.ac.ir

might handle dozens of products, supplied by many distributors, and the distributor in turn could supply many retailers. So, for the most part, upstream communication happens only through orders. Therefore, the teams were operating with perfect local knowledge but imperfect global knowledge.

The winner of the game is the team with the lowest overall inventory cost. The game was started in a state of equilibrium with four cases of beer in each of the shipping delays and customer orders at the retailer running at four cases per week. At the fifth week, customer orders at the retailer jumped to eight cases and remained at this level for the remainder of the game. The impact of this buying decision is reflected in the net inventory and ordering graphs of the teams shown in Figs. 1 to 4.

The graphs show that in response to the jump in retail sales in the fifth week, increased upstream orders were placed. Because of the shipping delays, these orders could not be filled immediately, and expensive backlogs resulted. To compensate for the backlogs and to provide a buffer, each supply chain point began placing larger upstream orders. When eventually, the backlogged orders began to be filled, so much beer was already in the supply chain that all points along the supply chain became grossly overstocked and had to drastically adjust their orders.

Interestingly, this boom-and-bust cycle was brought about by a single step in retail demand for beer in the fifth week of the game, after which this demand remained constant for the rest of the game.

The results in this instance of the Beer Game follow the pattern shown in many previous game sessions at different institutions and organisations [36-38]. Also in common with these other games sessions, the participants reported a sense of having little control over their ordering decisions and tended to see the root cause of their inventory problems as being caused by other points in the supply chain.

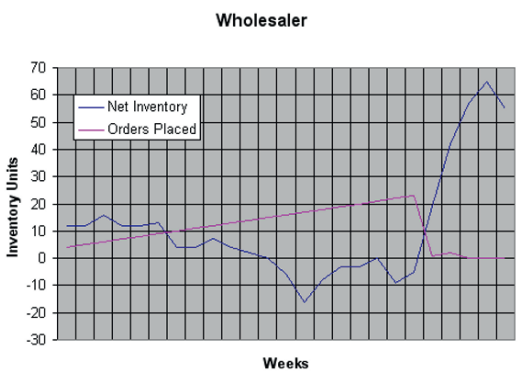


Fig. 1. Weekly net inventory and orders placed by the wholesaler.

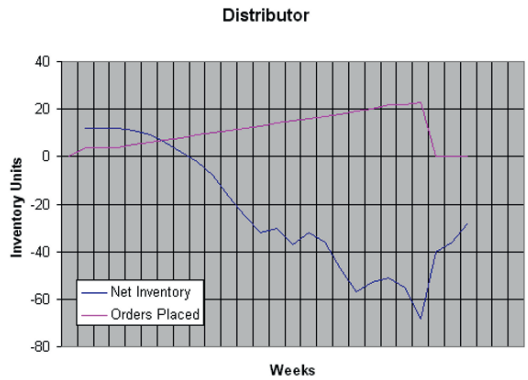


Fig. 2. Weekly net inventory and orders placed by the distributor.

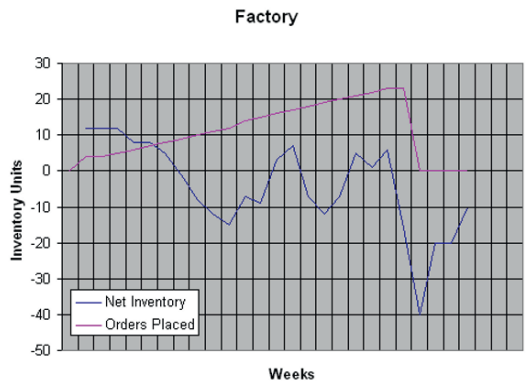


Fig. 3. Weekly net inventory and orders placed by the factory.

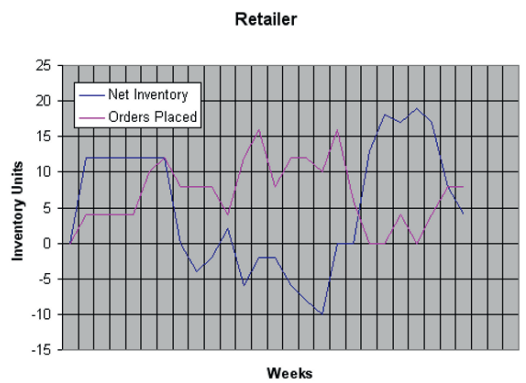


Fig. 4. Weekly net inventory and orders placed by the retailer.

IV. FURTHER RESEARCH

The Beer Game demonstration is part of an ongoing research project into ways that games can be used to understand a critical modern situation— software

mmeybodi@aut.ac.ir

engineering: the systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of software. Despite the name, software engineering may not enjoy the same standing as the more established engineering professions. Anecdotal evidence suggests that an urgent software crisis exists (a gap between expectations of software and the product and performance actually delivered) and has been growing since the 1960s. While quantitative data proving the existence of a software crisis is thin, it might be conceded that software engineering has room to do things better.

Bearing in mind the definitions of model, simulation and game given in the introduction, it can be said that the software development process has been modelled [39-42] and simulated [43-49] many times. However, games have been used much less frequently with perhaps just a few examples [50, 51]. The reason for this game imbalance within the field, and between software development and other fields needs to be more fully explored.

The existing models and simulations in the field have recognised the utility of applying disciplined, systematic, and quantifiable methods to software development, that is, they describe situations of software projects managed according to software engineering principles. As such, these models and simulations would naturally serve as a starting point for game development, yet many have not presented the field's body of knowledge in an intuitive way. For example, perhaps the most well-known simulation [43] contains over 300 underlying variables, doesn't have a way to interact with the model except through direct manipulation of these variables, and yet does not describe the development process in detail [52].

Set against these models and simulations is research that has compared the learning outcomes between a range of simple and more complex games. While the most complex game offered "the richest learning experience available, the game's very formidable appearance probably intimidated a number of players or forced them into a learning situation they were unprepared or unwilling to negotiate" [53]. The next most effective game in Wolfe's study was found to be the least complex, supporting similar research that showed relatively simple games can provide essentially the same benefits as the more complex [54-56]. Therefore, making games only as complex as absolutely necessary, or hiding unnecessary detail, could be a way of achieving the best learning outcomes while avoiding the player mortality (boredom and dropout) noted by Wolfe.

Furthermore, software is often developed within an ill-structured environmental context [57-63] that includes sometimes contradictory human and business priorities, meaning that a purely technical or logical model or simulation is not always the best guarantee of success. (One way to provide this context is to have the game function as a hub interlinked with other resources and issues, rather than a stand-alone device [64-66]).

To address some of these issues, a game named Simsoft is in development by the authors. Within Simsoft, teams of players will given a simulated software project to operate from start-up to the delivery of its objectives. Based on the starting scenario of the game, information provided during the game, and their own real-world experience, the players will make decisions about how to proceed— whether to hire more staff or reduce the number, whether to purchase certain equipment, what hours should be worked, how much time will be devoted to training, and so on. After each decision set has been entered by the players, the game will be run for its next time slice, (a day, week, month, quarter— whatever the game designer has determined). The game will then be in a new state which the players must interpret from the reports or dials or other interfaces the game provides. A fresh set of decisions can then be entered and the life of the simulated project continues.

Specifically, Simsoft will represent software project experiments much like those imagined by DeMarco [67].

Naturally, software-engineering-based games are not the only way in which a contribution could be made to better software project management. In recent years a number of organisations and academic institutions have initiated training programs that aim to more fully round the theoretical background of software practitioners, often mixing this with real-world projects [68, 69]. Yet, for the most part "students are learning their real world awareness in industry, working on real projects where their mistakes affect all around them" [70]. Games represent one way of combining theory and practice while mitigating the inherent dangers.

V. CONCLUSIONS

In many fields, games are a mature tool for instruction and research. For example war games have a lineage stretching back many thousand of years, or, if we apply more strict criteria, at least as far back as the seventeenth century [71]. Meanwhile business games, such as the Beer Game, have been informing, frustrating, and delighting managers, students, and researchers since the 1950s. In addition, information technology now makes it possible to develop games of incredible richness and verisimilitude. Despite this maturity in other fields, games have been less used in exploring issues around software development, presenting an opportunity to find out why this might be so and whether a suitable game can address current concerns.

However, applicable to any field in which games might be used, particularly those in which games are delivered via computers, Simon [72] asks a pertinent question: can a computerised representation of the real world, such as a simulation or game, ever tell us anything that we do not already know? Taking for granted two common and plausible assertions about such computerised representations— they can be no better than the assumptions built into it, and a computer can only do what it is programmed to do— then the answer to Simon's question might be, no. Yet, Simon argues otherwise. For example, even if we start with correct premises, it may be hard to infer meaning because humans generally have trouble

mmeybodi@aut.ac.ir

tracing through even a small set of causal relationships. A disinterested computerised representation is better able to do this. It may also be the case that in some circumstances, for some players, games may *only* tell us what we do not already know:

"It appears that for children, games are more than a caricature of life; they are an introduction to life— an introduction to the idea of rules, which are imposed on all alike, an introduction to the idea of playing under different sets of rules— that is, the idea of different roles, an introduction to the idea of aiding another person and of knowing that one can expect aid from another, an introduction to the idea of working toward a collective goal and investing oneself in a collectivity larger than oneself" [73].

Therefore, games may represent a serendipitous addition to the tool bag of researchers.

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mmeybodi@aut.ac.ir

A Tool to Support Self-Education in a Lifelong Learning

Dalia Baziukaitė
Email: dalia.baziukaite@ik.ku.lt

Žilvinas Vaira
Email: zilvinas.vaira@ik.ku.lt

Dominyka Idzelytė
Email: dominyka.idzelyte@ik.ku.lt

Department of Computer Science
Klaipėda University
LT-92294 Klaipėda
Lithuania

***Abstract*—This paper presents originally created and implemented course format *selfedu* for e-learning materials and activities that are placed in a virtual learning environment (VLE). Courses, which are published in *selfedu* way, are dedicated especially for self-education process, which is an important element in lifelong learning phenomenon. This format is based on Moodle ver. 1. 5 open source VLE and incorporates a set of student tools that in some amount guarantee a successful awareness of presented materials without assistance of a human tutor and a set of teacher tools that help to prepare and publish course materials in a proper way.**

I. Introduction

Virtual learning environments (VLEs) are broadly used at schools providing secondary, high and higher education. Universities are not an exception. Mainly, VLEs have become an integral part of a study process. They are applied in a pure distance education studies and also are successfully used to support full-time students. According to research done in Britain [4], [6] which is probably the most advanced country in Europe in this field, 90% of schools use VLE or even have more than one VLE system in the institution. The most popular are commercial Blackboard/WebCT[1] and open source Bodington[2] and Moodle[3]. For example, in Lithuania big universities prefer commercial Blackboard/WebCT and smaller ones use open source environments Moodle or ATutor[4]. Similar situation is in secondary schools [7]. It is clear that VLEs have won a strong base of application in a modern educational process.

According to statements about open distance learning, some of them can be referenced in [5], [8], in courses that are delivered in a distance way, a teacher is required to do more guidance, advisory and mentoring tasks. Still, even pure distance education studies can not be imagined without human tutor in them. Technology and tools we have today let us think and realize delegation of some tasks, which usually are performed by humans, to pure synthetic systems. The idea of a VLE with adaptive and intelligent features was defined in earlier work [2]. It was stated that the adaptivity is a system's ability to form and during the learning process uniformly update curriculum[5] that satisfies the needs of the learner; intelligence is expressed by the ability to initiate actions and, referring to the learning process, perform decision making processes by applying adopted artificial intelligence (i.e. machine learning) techniques.

The tool we talk about in this paper brings to the student a possibility to learn more systematically and probably quicker by following displayed instructions. Materials to be learnt are only those that are identified as required to be learnt. The process goes on without intervention of a human tutor.

Next section gives a short outline of conceptual model which was proposed for VLE with adaptive and intelligent features in [2]. Section III describes key structure elements of a new course format. Sections IV and V present a set of tools that are created for a student and teacher in order to successfully use environment in self-educative manner. Finally, Section VI provides future vision of works to be done and discussion on usefulness of the created product.

II. Idea of Adaptive and Intelligent VLE

The model proposed in [2] has been designed to have three parts that describe the main functionality of the adaptive and intelligent component:

- setting-up the student curriculum;
- teaching a student;
- controlling a student.

A. Setting-Up the Student Curriculum

The curriculum setup brings to a student the possibilities described in Table 1.

Every registered student (Learner) is able to construct the curriculum, which expresses specific needs of the user. In this case Learner has to enroll into a *selfedu* course and collect topics he/she would like to study. After collecting topics it is required to submit selection.

In *selfedu* courses Learner may define the level of desired excellence he/she wants to achieve in his/her curriculum. There

[1] http://www.blackboard.com
[2] http://bodington.org
[3] http://moodle.org
[4] http://www.atutor.ca

[5] We use "curriculum" for a sequence of course structure elements (such as courses, units, sections).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 92–97.
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mmeybodi@aut.ac.ir

are three possible levels of excellence: excellent (86%-100%), good (70%-85%), satisfactory (50%-69%). Learner can define the level of excellence in a curriculum settings control panel.

Learner is able to switch between several types of presentations of learning material. He/she is able to manage the amount of examples, graphical explanations and text in one qualified unit of the learning material. This is called managing of preferences and is performed through the curriculum settings control panel. This option remains available during the process of learning.

Before allowing Learner to deal with the learning material, verification of formed curriculum is performed. Verification starts automatically after submitting collection of topics in a *selfedu* course. Learner has the possibility to skip the verification. If Learner does not skip the verification the system acts towards identification of the current knowledge state of Learner in selected curriculum according the desired level of excellence (tries to identify topics that are really needed to be studied). After verification process is completed, topics that are suggested as not useful might be removed from current curriculum. Topics that are found to be needed, but still are not included into a given curriculum, appear with a link "add" near the title. Learner has an ability to accept system's suggestions or not.

B. Teaching a student

This part of the system is responsible for the decision-making. Decisions made form the activity chain, which shows actions how a student is trained. By activity, we mean the actions a system could perform, for example show the learning material, give a self-test, give a test for evaluation, etc. The activity should be selected according to the belief[6] the system has about a particular student [1]. Decisions should be made in order to guarantee the optimal number of learning units that are needed to be presented to the student, and are necessary for achievement of the predefined excellence level in the preformed curriculum.

TABLE I

POSSIBILITIES IN A SELFEDU COURSE FORMAT AVAILABLE TO STUDENT

Possibility	Event that should happen *before*	Event that should happen *after*
Collect topics	Enrollment to a course	Submission of designed curriculum
Set desired level of excellence	Collection of topics	---[7]
Set preferences	Collection of topics	---
Start verification	Submission of designed curriculum	Correction of curriculum
Add/Drop topics	Completed verification	---
View student model	Submission of designed curriculum	---

[6] Belief expresses knowledge a system has about learner's mental state, which is captured in a student model.

[7] No specially required event.

C. Controlling a Student

Student's control is defined by deciding when to give an evaluative test or other activity that could assess a particular student's knowledge in a certain part of the curriculum. After completion of an evaluative activity the system must update its belief about a particular student in order to change its state. The decision-making process in the student controlling activity is based on the same principals as decision-making in the student teaching activity. The intelligent aspects of such system are described in more detail in [1]. In this paper we concentrate on the adaptive features of the format.

III. STRUCTURE OF SELFEDU COURSE FORMAT

The structure of *selfedu* format is based on three key elements:

$$\text{Course} \rightarrow \text{Unit} \rightarrow \text{Section},$$

that build a hierarchical structure of *selfedu* course. Section is a smallest element equal to one topic in a course, which can be described in one resource file, not "longer" than two screens. Collection of related sections build unit and units build one course. Building like that allows dependencies between ability to answer questions right and sections included into the learner's curriculum to be checked. Checking is done during a verification process, which starts after submitting curriculum or at any other moment when the learner wishes to perform it.

Bellow we describe the idea of a mechanism, which enables automatic creation of verification tests and more explicitly explains relations between course structure elements.

Let the U be the universal set of courses that consists from n different elements

$$U = \left\{ \bigcup_{i=1}^{n} U_i \right\}. \quad (1)$$

Each subset $U_i \subset U$ is made from the set of units C

$$U_i = \left\{ \bigcup_{k=1}^{m} C_{ik} \right\}. \quad (2)$$

Each subset $C_{ik} \subset C \subset U_i$ is made from the set of sections S

$$C_{ik} = \left\{ \bigcup_{i=1}^{l} S_{kj} \right\}. \quad (3)$$

The section S_{ki} has no index i identifying the dependency to the course because of an idea, that section can appear only inside a unit and it's relation is defined by the index k, that corresponds to a unit.

Each subset S_{kj} is made from the set of topics P

$$S_{kj} = \left\{ \bigcup_{\upsilon=1}^{\kappa} P_{j\upsilon} \right\}. \quad (4)$$

The set of topics $\{P_{i\upsilon}\}$ is a subset of a set P. Combining definitions (1) – (4) we obtain

$$U = \left\{ \bigcup_{i=1}^{n} \bigcup_{k=1}^{m} \bigcup_{j=1}^{l} \bigcup_{\upsilon=1}^{\kappa} P_{ikj\upsilon} \right\}, \quad (5)$$

where $\{i,k,j,\upsilon\}$ is a set of indexes, $n,m,l,\kappa : (n,m,l,\kappa) \in Z$, υ identifies the topic. Definition (5) has a meaning that each topic is unique by its combination of four identifiers, representing relation with particular course, unit, and section and defining a specific topic itself.

mmeybodi@aut.ac.ir

Let $Q=\{q_\gamma\}$ be a set of questions. Each question q_γ has to represent the knowledge from defined section S_{kj} (set of topics $\cup P_{j\upsilon}$). So we have that

$$Q=\left\{\bigcup_j\bigcup_\gamma q_{j\gamma}\right\}, \quad (6)$$

where j is the section identifier, γ is the number of question (question identifier).

Let $A=\{a_\xi\}$ be the set of possible answers related with the appropriate question q_γ.

$$A=\left\{\bigcup_\gamma\bigcup_\xi a_{\gamma\xi}\right\}, \quad (7)$$

where γ is the question identifier; ξ is the answer identifier.

Let $A^*=\{a^*_\xi\}$ be the set of the defined right answers. $A^*=\{a^*_\xi\}$ is a subset of the set $A=\{a_\xi\}$

$$A^*=\left\{\bigcup_\gamma\bigcup_\xi a^*_{\gamma\xi}\right\}. \quad (8)$$

Let the set $A^U=\{a^U_\xi\}$ describes the answers that the learner gives to the questions system displays. Then the A^U can be defined as a sequence of ones $\{1,...,1\}$ for the answers that matches the defined right answers and a sequence of zeros $\{0,...,0\}$ representing the answers that do not match with the defined right answers.

$$A^U=\begin{cases}\{1,...,1\}, a_{\gamma\xi}=a^*_{\gamma\xi}\\ \{0,...,0\}, a_{\gamma\xi}\neq a^*_{\gamma\xi}\end{cases}. \quad (9)$$

The sequence of zeros in the definition (9) can be change with the sequence of topics that are represented by the question. The same, the sequence of ones can be change by the modified sections / units, represented by the questions. So, to uniquely define topic four identifiers are required, and to uniquely define dependence of an answer to the question two identifiers are enough.

Logic from above is used when system automatically selects questions, which are need to be included into a verification test according to given learner's curriculum. After verification, taking into account relation between question and topic system considers what topics might be removed or added.

IV. SELFEDU IN ACTION – STUDENT'S VIEW

In a modified version of Moodle ver.1.5 VLE, a user having student's role can connect to a system and enroll to *selfedu* courses. VLE will show a structure of units and topics (sections) in them, which is filled with learning materials and activities of special type. Every unit or topic can become „selected" or „unselected" (Fig. 1). To create his/her own learning curriculum Learner has to perform two steps: 1) select topics or units that express learning goals of particular learner by clicking „select" and 2) save the selection by clicking „Save Curriculum" button (Fig. 1). After saving, Learner is asked to accomplish a verification test (Fig. 2). Learner can proceed to or skip verification. If skipped, it can be started at any other moment by clicking „Start verification test" in „Control panel" block. Verification test will be automatically generated from questions that have relation with topics within the Learner's curriculum. Questions, to be included in the quiz, are selected randomly. The amount of questions in verification test depends on the number of questions associated with a particular topic.

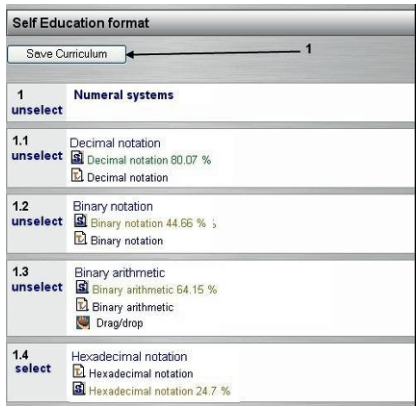


Fig. 1. Student's view with possibility of selecting topics and sections; 1- button to save selection

Limits for number of questions per topic (Fig. 3) are defined according this rule: if the number of questions associated with particular topic do not exceed 5, then there will be only 1 question in verification test representing that topic; if there are 6 to 15, then there will be 2 in verification test; and if there are more than 15, then there will be 5 questions in verification test. To finish verification, Learner has to submit answers by clicking „Save verification test" (Fig. 3). Now, suggestions for curriculum update appear (Fig. 4). Learner can use „Control Panel" block (Fig. 3) in order to view his/her own results, set preferences, define desired level of excellence or start verification process again.

The suggestions for curriculum update are given by the system according to the formula bellow:

$$r_i=\frac{count(a_{\gamma\xi}=a^*_{\gamma\xi})}{N}\cdot 100\% \quad (10)$$

where r_i is a result for *i*th topic in the curriculum, $count(a_{\gamma\xi}=a^*_{\gamma\xi})$ is a number of correct answers given by Leaner to questions in relation with topic r_i and N is a total number of questions per topic included in the given verification test. The following rule can be derived from formula (10): if computed r_i is less than 85%, system will display no suggestion for that topic; if result is 86% to 100%, system will suggest to drop particular topic from the curriculum (Fig. 4).

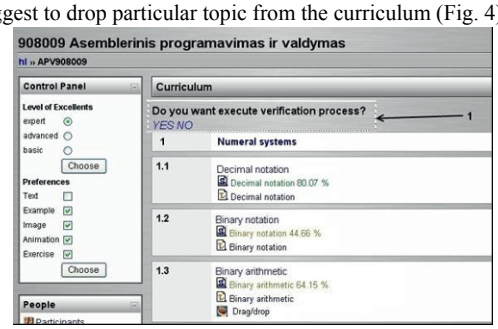


Fig. 2. Student's view after saving selected curriculum: 1- system is asking to start verification process

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Fig. 3. Student's view with automatically generated verification test: 1 – button to save answers, 2 – start verification link

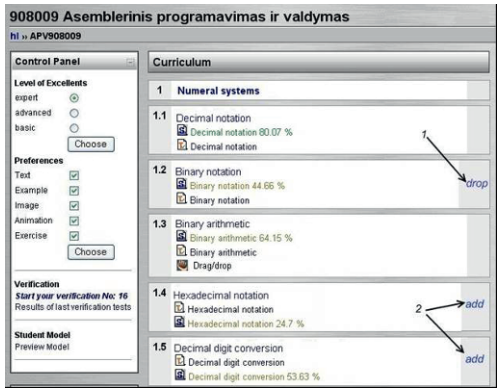


Fig. 4. Student's view with suggestions after completion of verification: 1 – link to drop topic, 2 – link to add topic

In case, when Learner gives a wrong answer to a question, which has relation to topic not in the curriculum, system will suggest adding it (Fig. 4).

Option "Student model" in the "Control Panel" block provides information about learning process of given Learner. Learner can analyze his/her learning steps with a help of presented diagrams and displayed suggestions. At first, static preferences, such as color legend, selected learning material type and etc., of the model are presented (Fig. 5). Links to resources are presented in different colors with marks of percentage values (as can be seen from Fig. 1, 2 and 4). Color map is explained in a color legend, where each color represents some interval of values. These values depict learning intensity of a student. Representation like that has a benefit when learning process lasts long time. This can help to track a display time of each resource to Learner.

To implement the structure described above, new components have been implemented in database for saving learner's activity of resource reading. This history is also used for all calculations represented by student model. History connected to given Learner is automatically removed after removing Learner's account and a part of it is removed in case some resources are deleted from the appropriate course.

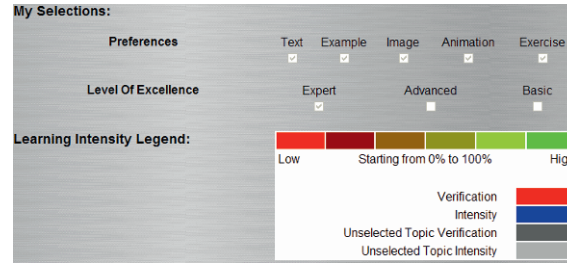


Fig. 5. Static preferences of a Student Model

Every resource can be viewed unlimited time. An indirect measure of time is used to calculate a resource display statistics. This is a calculated measure that depends on the whole period for how many times resource was being displayed to Learner. Such method is less precise, but easier to implement. To prevent possibility of "cheating", when student can perform large amount of clicks, special formula is used in calculation. It prevents from getting over 100%.

In "Student Model" some diagrams[8] are available for Learner. Diagram in Fig. 6 is used to represent a reading intensity of learning resources and comparison of quiz results. Topics that are not a part of Learners curriculum are displayed in grey, quiz results for topic in curriculum are displayed in red and reading intensity in blue. In [3] visual representation of learner's data is used for teacher to see learner's activity during the learning period. Teachers, usually, have professional expert skills to effectively analyze them, but for students they can seem to be too complex. Learner can be unable to correctly notice failures or achievements of his/her own learning process. Simple diagrams and suggestions that are inferred from log data are used for this purpose. Suggestions (Fig. 7) help Learner to analyze presented diagrams and decide further actions. Suggestions consist of topic number, suggestion text and link. Topic number points to the particular topic. Suggestion text is generated according to a history data. The link allows taking action without browsing into a course.

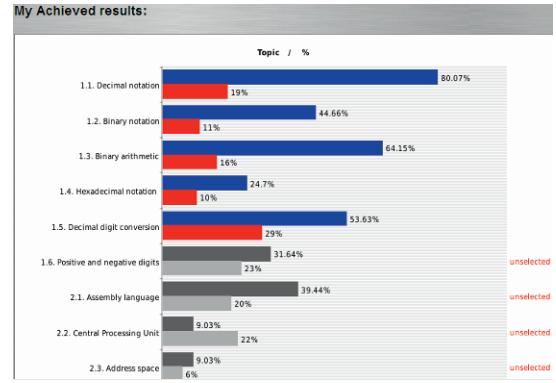


Fig. 6. Diagram representing reading intensity of materials and quiz results of topics in curriculum

[8] To create diagrams some graphics libraries under GNU license are used, http://naku.dohcrew.com/libchart/pages/introduction

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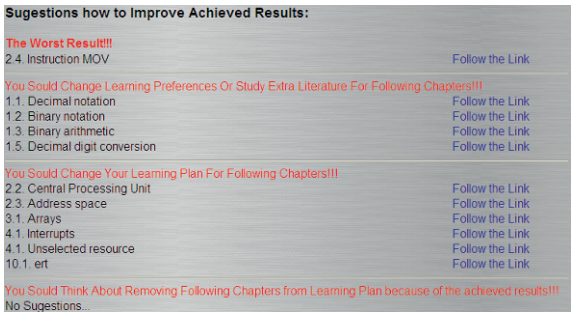


Fig. 7. Some available suggestions

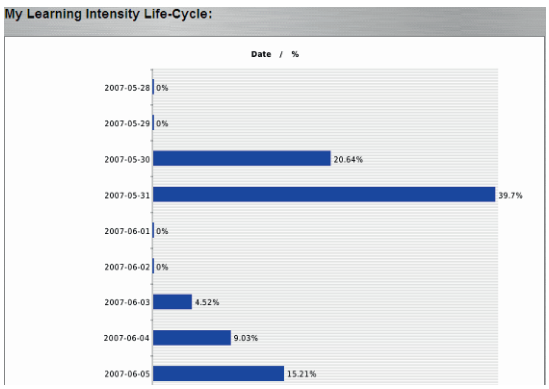


Fig. 8. View of learning intensity diagram

Suggestions are generated for the worst result in learning process, according to the changes to be done in Learners curriculum, according extra reading of learning material or changing learning preferences and etc. All this allows Learner easier to understand his learning process and take appropriate actions. Learning intensity diagram (Fig. 8) represents activity of given Learner during the whole learning process. This diagram does not include topics; Learner can analyze his/her own learning process in a perspective of time.

V. Teacher Tools

Success of effective usage of self-educated course mainly depends on a teacher. Teacher is a person who follows the philosophy of self-educated course format [2], [1], designs course and publishes resources. Mainly, topic should include learning material and standard evaluative activity (i.e. quiz). It is also available to add any other Moodle activity or resource to the topic. We call such resources extra learning material. Specially designed resource for self-education can be added only once in one topic.

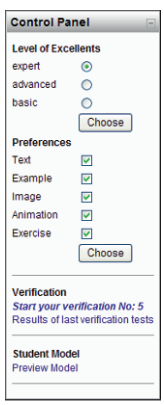


Fig. 9. "Control Panel" block

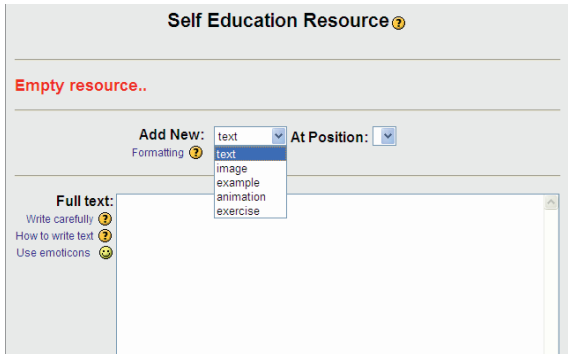


Fig. 10. Insertion of text item in self-educated resource

When adding resource for self-education, teacher first has to fill in a title and subtitle of the resource and define standard resource settings like in every usual Moodle resource. After clicking "Next" teacher will be redirected to the second part of resource editing form, which is specially designed for self-educated course resources. At certain moment an empty resource (Fig. 10) is saved into a database. This allows a teacher only put resource titles first and come back for editing later.

Resources are filled in by parts. As displayed in the "Control Panel" block (Fig. 9), resource can consist of five types of learning materials (text, example, image, animation, exercise).

Insertion of these different items into a resource is implemented through a specially designed form, which dynamically changes after selecting type of material. Different types of resource items are added continuously one after another (Fig. 11), and can be edited independently. The result of such a composition is displayed in a standard resource manner, without separating components to the sequence they were added. A preview mode is available after clicking "Finish". If "Edit resource" is clicked, one returns to the resource editing mode. Every item in a self-educated course resource can be edited or deleted at any time. Sequence of item representation can be changed at any time as well.

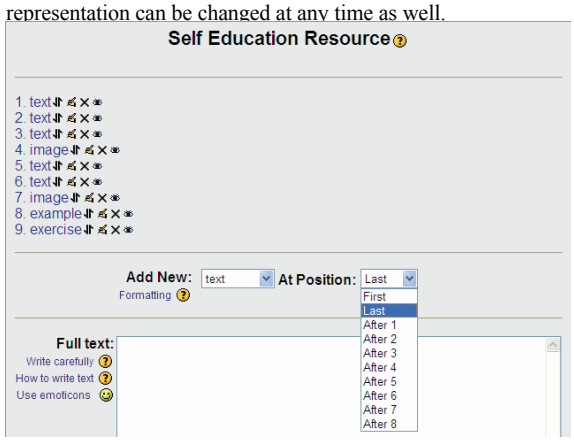


Fig. 11. Construction of self education resource from several types of items

mmeybodi@aut.ac.ir

In student's view, depending on Learner's setting in "Control Panel" block (which is only available in student's view), self-educated resources can be displayed in several ways, i. e. displaying only text items, exercises and etc, or combining them, or using default presentation – displaying all available items.

Main requirement for successful preparation of self-educated course is that a teacher correctly understands the idea of such course format and is able to build qualified and structured course materials.

VI. Final Remarks

Results of this work represent adaptive part of the idea, which in short is expressed in Section I and is described in details in [2]. Two more steps are required to be accomplished in order to achieve perfect result. These are 1) implementation of conceptually designed intelligent features of the system and 2) quality testing of learning results in two cases: first, when students are guided trough the course by human tutor and second, when tutor's function is dedicated to the system itself.

The implementation of a new course format into a VLE has enriched the spectrum of a student's own abilities to purposefully, without the extra help of a tutor, seek some level of acquisition. This adds a value for the self-education possibilities when VLE is applied in the study process. It also has added a new feature of the adaptive curriculum formation - a novice feature that allows for each student independently express a learning goal in terms of "desired" topics. Installed topics and knowledge verification mechanism ensures that each student curriculum consists only of materials that are considered as really needed.

At the current moment the implemented component with adaptive and intelligent features for VLE is in highly experimental stage, but already is available for external testing[9] and allows users to login. Testing is available both for set of student tools and for set of teacher tools.

[9] http://cs.ku.lt/~avma

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mmeybodi@aut.ac.ir

Postgraduate Distance E-Learning Programme on IT in Construction

Danijel Rebolj
University of Maribor, Faculty of Civil Engineering
Smetanova 17, 2000 Maribor, Slovenia

***Abstract*-The paper is presenting an interuniversity postgraduate program on information technology (IT) in construction, which is offered by a consortium of European universities. Concepts, the development process, technical solutions, experiences and plans for further development of the program are described.**

I. INTRODUCTION

Human collaboration is a very strong method for solving problems. On one hand it can use resources effectively, in the first place knowledge and expertise, which is leading to desired synergy effects. On the other hand it leads to exchange of knowledge, which is resulting in a higher level of balance. Brainstorming, which means an extreme in mental collaboration, is often leading to innovation and thus to enriching of the society. If collaborators are joining from many different countries, the effects are even stronger and the results can have global effects.

In the past decade, after the Internet collaboration tools have been developed to a more mature level [1], projects have started with the aim to explore and experience the developing collaboration tools and to bring together experts from different professional as well as cultural areas. Works have been published on successful engineering collaboration between students of different universities working (and learning) on common projects. Fruchter [2] reported on combined research and curriculum development for multidisciplinary, geographically distributed architecture / engineering / construction (AEC) teamwork. She presented a model for a distributed AEC learning environment and an Internet-based Web-mediated collaboration tool kit. Other successful attempts were reported from different research networks (e.g. [3]).

II. THE ITC EUROMASTER EXPERIENCE

One such attempt has been the Information Technology in Construction (ITC) joint curriculum development project, ITC Euromaster (described in more details in [4] and [5]). In 2001 seven European universities started to develop a new postgraduate program in ITC. The program development has been funded by the European Commission in the Socrates / Erasmus framework between 2001 and 2003, and again in between 2004 and 2005, when two further partners joined the program dissemination process. The following partners have been active in the program development and dissemination (in alphabetical order): Universidade do Algarve (Portugal), Technische Universiteit Delft (Nederlands), Technische Universität Dresden (Germany), Glasgow Caledonian University (UK), Universidade nova de Lisboa (Portugal), Univerza v Ljubljani (Slovenia), Lulea University of Technology (Sweden), Univerza v Mariboru (Slovenia; coordinator of the project), University of Salford (UK). In the academic year 2006/2007 University College Cork (Ireland) and Technische Universität Graz (Austria) have joined the partner consortium.

The main purpose of the project was to develop a curriculum on IT in Construction to give students the possibility to extend their knowledge in research, development, and application of computer and information science in civil and building engineering. The result, a European Masters curriculum in ITC, complements the existing portfolio of teaching programs and should meet the growing demand for such skills. In the case of those institutions already offering ITC courses, the project is providing the added value of a European dimension for their existing ITC program.

The development of the content and of the teaching material of each subject has been coordinated by a responsible partner. Teaching materials have been prepared in digital form to conform to the e-learning standards. At the University of Maribor and University of Ljubljana the program has been accredited in its full content and started in autumn 2004. Delft University and Dresden University are contributing up to three courses to the program and integrate them into their already accredited curricula.

The curriculum was focused on students who have finished their undergraduate studies with a university degree in civil, building or structural engineering as well as architecture. The program graduates will earn a new "European Master on Information Technology in Construction" academic degree, which shall enable them to continue with the relevant PhD study, or immediately start to work in the industries as civil engineers with a specific focus on Information Technology. The need for such new profile has already been recognized by different authors (e.g. [6]).

We are convinced that the civil and building industry will need more engineers with profound IT understanding and knowledge in the e-society of tomorrow. Offering courses in the proposed distributed way will give the students the best existing knowledge and quality in the ITC field, enriched with the multicultural dimension.

The only way to support collaboration of so many different universities was in using an effective e-learning system. According to our experiences a firm technical infrastructure is a vital part of any such system. So far we have gathered experiences at experimental e-learning supported seminars (see

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 98–101.
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[5] for details) and in various other projects, where audio or videoconferencing (HorizonLive, VCON, CUSeeme, ClickToMeet) and different web based content delivery systems have been used (Blackboard, Fgweb, Moodle).

The current ITC Euromaster e-learning environment consists of two components: the course management system, which is the entry point to the program [7], and the Virtual classroom. The main function of the first is to enable access to teaching and learning materials as well as other relevant functions (e.g. forums) and information (e.g. teacher and student lists, timetables etc.) from any location on the Internet. The course management system (Fig. 1) is based on the Modular Object-Oriented Dynamic Learning Environment [8].

The Virtual classroom is supported by ClickToMeet videoconferencing system, which enables teachers to directly communicate with their classes. A participant list, chat, audio and video control, web touring, document sharing, application sharing and a whiteboard are the basic parts of the virtual classroom (Fig. 2). Both systems are interlinked and function as a single integrated system.

In the academic year 2004/2005 five courses have been successfully delivered with five students logged in individually and some more students, who have followed the lectures from a classroom at TU Dresden. Except of some audio fine-tuning and bandwidth problems at the beginning of the semester the lectures run perfectly throughout the semester. In 2005/2006 both years' courses were fully running and in 2006/2007 altogether 13 teachers and 32 students were registered in the program.

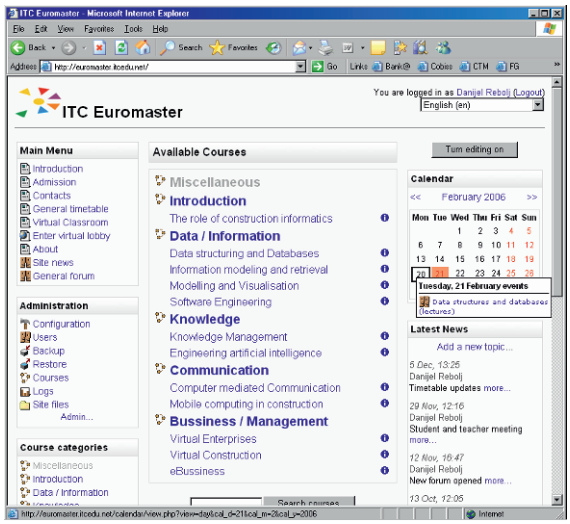


Fig. 1. The Course management system of the ITC Euromaster program.

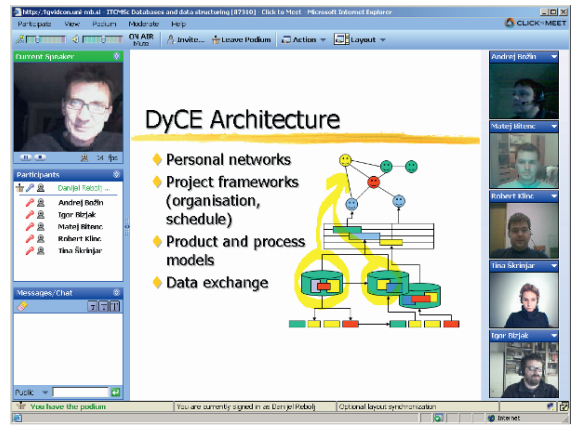


Fig. 2: The Virtual classroom of the ITC Euromaster program.

III. FURTHER DEVELOPMENT OF THE E-LEARNING ENVIRONMENT

The authors are not aware of any commercially available modular system that would fully support a virtual learning centre. This fact, but also the extremely fast development of software for synchronous collaboration support, and the maturity of the software component technology, strengthened our conviction to design a system that would allow gradual development, first covering ITC Euromaster course, and later evolving into a "virtual university campus".

The conceptual schema is based on the following main requirements:

- program, teacher, student and subject related teaching and learning content storing and delivery
- class related point-to-point and multi-point audio& video communication
- class related instant messaging

The relevant entities are depicted on Fig. 3 and the main functions shown in Table I.

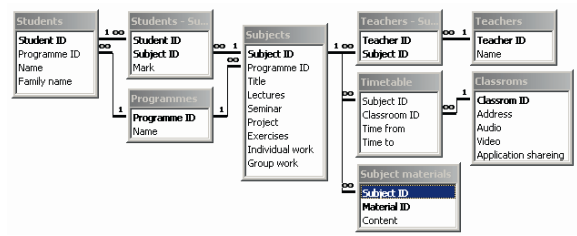


Fig. 3: Relationships of the main entities of a Virtual Learning Centre.

mmeybodi@aut.ac.ir

TABLE I
COMMUNICATION MODES BETWEEN ACTORS (ACTIVE ENTITIES)

		Communication	
Initiator	Respondent	mode	function
Teacher	Student	Interactive	chat, audio, video, app. sharing
Teacher	Class (Students)	Interactive	chat, audio, video, app. sharing
Teacher	Subject	RWED	text, graphics, animation
Student	Teacher	Interactive	chat, audio, video, app. sharing
Student	Class (Students)	Interactive	chat, audio, video, app. sharing
Student	Subject	RE	text, graphics, animation

The most important required characteristics of the system are scalability, modularity and interoperability. Wherever possible, standard software components or interoperable software modules will be used. The system should not exceed an easy manageable level of complexity and should not become huge or monolithic. Modularity should be kept at the user interface level as well. The following example shows a prototype of a virtual classroom user interface (Fig. 4), consisting of:

- personal calendars
- instant messaging system, which becomes a picture of the class by applying certain selection criteria based on context parameters like program, subject, date and time
- teaching material management, presentation and sharing
- videoconference system, which serves for vocal and visual communication between teachers and students

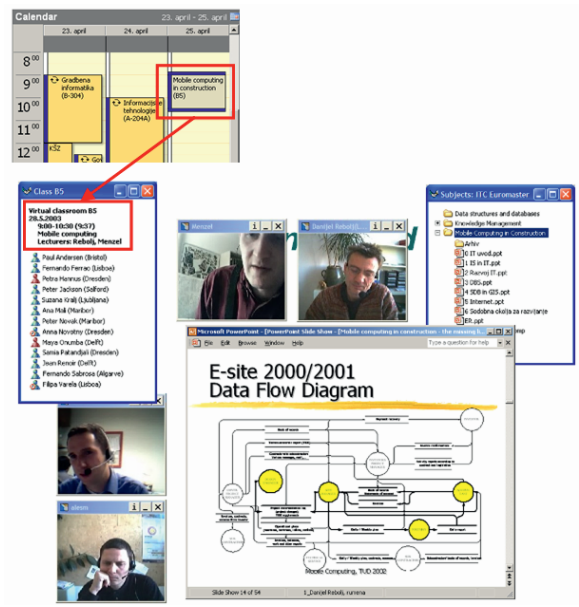


Fig. 4: prototype of the new virtual classroom user interface

Only the necessary information is shown on the user interface: the list of relevant students (including their status and optionally voice and video), teachers (voice and video), subject (relevant teaching material). Each participant is able to shape her or his arrangement of information on the screen.

Of course the technical infrastructure is only one of the many dimensions of a virtual university. Organizing virtual courses, managing classes, managing the virtual institution in general, are certainly exacting tasks, which we expect to master through the ITC Euromaster program. On the other hand certain training is needed for lecturers. Lecturers need to learn how to interact with remote audience by "evading" technical limitations and complementary usage of technical advantages. Each lecturer must develop "trust" into the technical environment and a certain level of practice in dealing with all components of such environments. However, one should never forget that the pure availability of technical equipment does not automatically improve the quality of teaching. The methods of teaching need to be modified or extended according to the specific capabilities of the integrated technical system.

IV. THE ITC COURSE POOL AS A NEW COLLABORATION PROMOTER

The accreditation process of a joint study program proved to be a problem, since different rules are in power in such many different countries and universities. To overcome formal obstacles and to open the program to the global community we have decided to form an open pool of ITC related courses. The initial ITC course pool has started to accept courses developed in the ITC Euromaster project. However, any institution with knowledge in the ITC field is welcomed to offer a course to the pool. Once accepted by the steering committee, the new partner institution can include any number of existing courses in its own program, since the pool is based on reciprocity (Fig. 5). Any unbalances in students and courses will be regulated by the steering committee. One way of balancing is for example by requesting further supporting staff from a partner having more students in a specific course given by another partner.

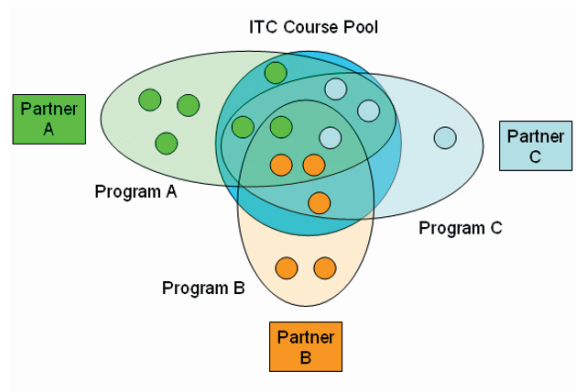


Fig. 5: The ITC Course Pool concept

mmeybodi@aut.ac.ir

From the technical viewpoint joining the ITC course pool is easy. The agreement is available at the ITC@EDU network web page [9]. The appendix of the agreement consists of the template of the Accession declaration to the ITC Course Pool, which includes the institution wanting to join, the offered courses, and nomination of the steering committee member. Once the document is accepted by the steering committee the courses are at disposal for all members. The acceptance procedure shall among others include the quality check of the offered course materials.

The ITC course pool will need a strong support from collaborating institutions. The experiences in the current ITC Euromaster program showed that much effort is necessary to prepare high quality e-learning materials, to become familiar with the on-line communication, to manage and further develop the e-learning system, and to coordinate the whole program. But even in the short term the investments give a high return. Having a whole pool of courses at hand certainly gives each partner a strong background to form a whole new program and to offer their students specialized knowledge and skills which they could possibly never be able to offer by themselves.

V. Conclusion

A broad range of knowledge can be delivered to anyone who seeks it by bringing together the best expertise in teaching IT in Construction subjects. The main objective of the ITC Euromaster project was to organize the knowledge in the field of IT in Construction and to develop an effective environment to support "collaborative learning scenarios" with distributed teachers and students. The establishment of a "community spirit" bears at least the same importance for the success of the developed program as the implementation and configuration of the IT platform.

In this paper, we have shown that there is still a lack of effective modular, integrated e-learning environments required to support distributed students and teachers; but we have also shown, by our own example, that the demand and opportunity for such environments are growing fast. Integrated e-learning environments will become the basis for a virtual university, linking together teachers and students of multiple nations and continents.

The only requirement for the student of tomorrow should be curiosity and the will to learn- nothing else. For this reason, we will continue to develop new content for the ITC Euromaster course pool, improved management patterns for the ITC Euromaster Network and continuous support for the ITC@EDU Workshop series. We hope that we will be able to weave a global network of interested partners with the support of Erasmus Mundus.

VI. Acknowledgments

We would like to thank the European Commission for funding the ITC Euromaster Erasmus development and dissemination projects.

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mmeybodi@aut.ac.ir

A Hybrid Lab for Evaluation of Analog ASICs

Michael E. Auer[1], Danilo Garbi Zutin[1], IEEE Members
[1]Carinthia University of Applied Sciences
Europastrasse 4
A-9524, Villach/Austria

***Abstract*- Laboratories are collections of experiments. We differentiate virtual (simulations) and remote (control of real hardware) experiments. In this work we present an analog ASIC design and test system. The software for the creation, verification and possible simulation of designs and downloading them to the hardware device is running on an Application Server. In this way the user can remotely download the desired circuit design to the device. He can than interact with this programmable hardware via the Internet by setting the parameters of the circuit input (waveform, frequency, amplitude, offset). After the parameters have been set the user can read the circuit output and compare the output signals with the input waveform signal on a virtual instrument on his client PC.**

I. Introduction

The overall goal in the field of engineering education is to prepare students to practice engineering. At this point, laboratories have an important role in an engineering course curriculum due to its ability in aggregating knowledge and experience beyond theoretical lessons. In addition to that, the new trends of distance education are working to bring these facilities closer to the users whenever and wherever they are.

Remote Solutions applied to engineering teaching laboratories have been shown to be attractive tools in enhancing access to practical experiments. This, in combination with today's easy access to broadband internet connection, is transforming the way e-learning is carried out, allowing a higher level of interactivity and providing virtual environments closer to the real environments.

This work presents a solution to carry out some real typical experiments required in electronics courses through the internet. The remote electronic platform introduced here consists of web based environments accessible via a standard web browser for performing experiments with an ASIC (application specific integrated circuit). The system facilitates also the use of virtual instruments to carry out exercises with analog functions. The user can set different types of waveform signals, as well as change their characteristics (amplitude, offset, frequency) and work around the different possibilities offered by the system. Besides to applying signals, it is also possible to read the circuit responses and compare, for example, input and output signals in order to understand the behaviour of the circuit. An extra feature provided by the virtual instruments designed for the ASIC system also allows performing measurements with the signals acquired, like voltage (peak-to-peak, average and RMS), frequency and period of the waveform.

The facility to design and upload the circuit to the ASIC device is delivered by an application server. Even though the application server supports several simultaneous connections, only one user can access and perform exercises with the systems at a time, once the hardware is unique and the system doesn't support at the present a time sharing control.

II. System Description

The system can be described in general by Fig.1.

The web server hosts the HTML files that contain the ASIC laboratory home page with information about the implemented exercises, as well as the links to log on the system and it is located, in our case, apart from the LabVIEW server. The LabVIEW server is connected to the ASIC via the DAQ (Data Acquisition) card and therefore controls all the data acquisition and generation for the experiments, as well as all the measurements performed. The Citrix Server is the application server that hosts and delivers the *PAC-Design* application software in order that remote users could create schematics for the ispPAC10.

A. The Circuit Under Test

In order to create a higher level of interactivity with the user and facilitate the access to different features of the ASIC, it was assembled a new PCB. Within this board, each DAQ card terminal was directly connected to its respective node in the circuit. Fig. 2 shows the REL board.

The ispPAC10 is member of a family of analog circuits capable of realizing a variety of popular analog functions including precision filtering, summing/differencing, gain/attenuation and integration. The ispPAC10 operates within a voltage range that goes from 1 up to 4V. Once all performed experiments were carried out in single ended mode, all the inverter analog inputs were connected to VREFOUT (2.5V).

The assembled board also contains all necessary circuitry, like voltage regulators and one analog multiplexer to facilitate the selection of inputs to apply signals. It is also possible to make measurements with external devices once jumpers allow the connection of inputs and outputs to coaxial connectors.

The application software used to design the desired circuit within the ispPAC10 is the PAC-Designer software, also from Lattice Semiconductor.

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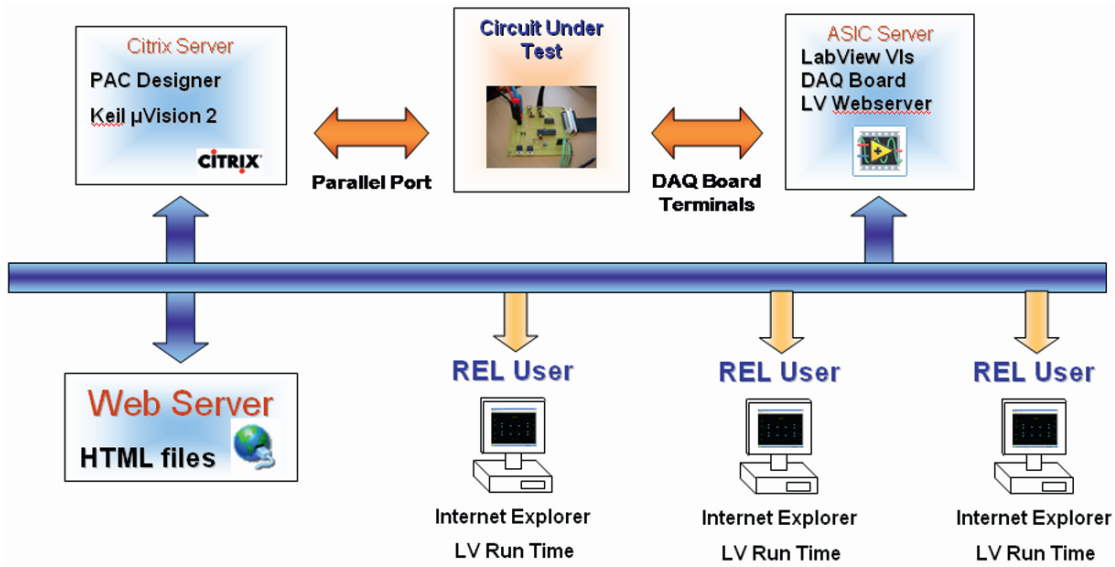


Fig. 1. The Remote ASIC Design and Test System's diagram.

B. The LabVIEW Webserver and the ASIC

As mentioned earlier, the LabVIEW server controls the hardware of the ASIC remote laboratory. This server runs LabVIEW and LabVIEW virtual instruments and also LabVIEW web server.

The data acquisition device used for this application is the PCI 6251, from National Instruments. This device offers two analog outputs and 16 analog inputs, with sampling rates of 1.25 MS/s and 2.86 MS/s respectively. This DAQ card also offers 24 digital input/output lines.

To control the data acquisition and signal generation, were used the NI DAQmx driver software, that can be called from LabVIEW to program NI measurement devices. The driver software has an application programming interface (API), which is a library of VIs, functions, classes, attributes, and properties for creating applications with data acquisition.

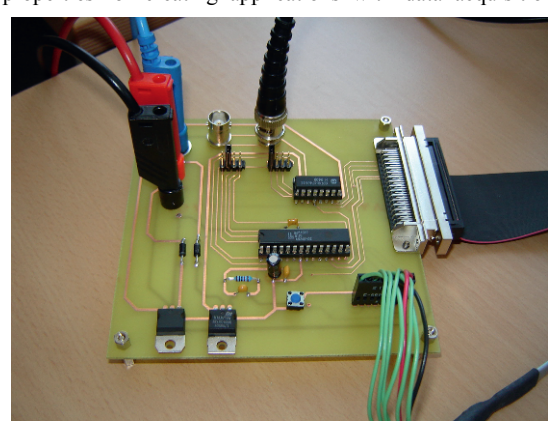


Fig. 2. The remote ASIC design and test board.

The development of the virtual instruments can be divided into three parts, the virtual oscilloscope, the virtual function generator and the user access control.

The oscilloscope VI carries out the data acquisition operation and also performs measurements with the acquired signals. These measurements can be the signal amplitude, average and RMS values, frequency or period.

Different parameters must be specified to set up a data acquisition. They can be the sampling rate and the number of samples to acquire (in case of a non continuous acquisition). Our approach to implement the system uses a non continuous acquisition. The system responds to a user command and samples the signal a specified number of times, which can be set by the programmer. In order to prevent aliasing, the number of samples acquired and the sampling rate are adjusted based on the time interval that the user wishes to visualize. LabVIEW treats this signal as an array of points and therefore uses it to calculate the different measurements. By combining the proper number of samples acquired and the sampling rate, it is possible to control the time interval read by the DAQ card.

The virtual function generator generates the signal for the circuit inputs. Therefore, it must facilitate the generation of different waveform signals, as well as to changing its parameters (frequency, amplitude and offset). The user sends the waveform parameters and the VI performs a continuous generation. It means that samples are generated continuously while exercises are carried out. This is possible due to the multithreading characteristics of LabVIEW and to some hardware characteristics. The DAQ device has two analog output channels that implement a FIFO buffer for continuous analog waveform generation and the waveform being generated can use the FIFO as a circular buffer, and continuously regenerate a series of analog values without any further updates from the host. This relies less on the availability of the communications bus, since data isn't constantly being streamed to the device. If the waveform needs to be modified, however, the task must be restarted in order to write new data to the FIFO [9]. The function generator VI uses the frequency value entered by the user to adjust the sampling rate and the number of samples per

mmeybodi@aut.ac.ir

buffer/period (N). In order to ensure a good quality of the signal, the N parameter was set to have a minimum value of 10 samples.

The diagram of Fig. 3 describes the communication between client and server.

The client sends the parameters to the server (*channels, timebase, inputs/outputs to read, etc*) and receives back the measurements and the waveform graph.

C. The User Access Control

The user access control carries out the authentication of the remote user on the system. This virtual instrument is the only one that is kept running while there is no user

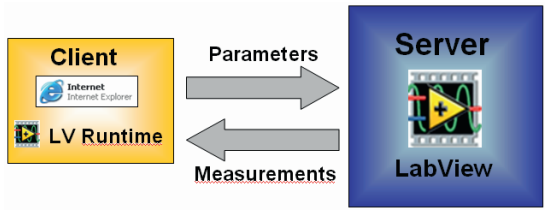


Fig. 3. Diagram that represents the communication between the client and the server.

connected. It waits until a connection is established and checks the user's login name and password stored in a simple text file. If the system finds the entries on the file a thirty minutes session is created. The access to the oscilloscope and function generator is enabled when one user is successfully logged in and the user can use the ASIC remote lab during this session. The session is closed either if time out occurs or by a user command.

D. The User Interface

The user interfaces of the system are the LabVIEW front panels of the virtual instruments.

To turn these virtual instruments available for remote users it was used a web publishing tool, also available in LabVIEW. This tool facilitates to creating HTML files with embedded front panels and also to publishing these virtual instruments with the LabVIEW Built-in web server.

The front panels are remotely reachable via a standard web browser and they were designed in a way that the user doesn't need any knowledge in LabVIEW to take advantages of the system facilities. Therefore, the client simply needs a web browser and the proper version of LabVIEW Run-time Engine that contains some libraries and web browses' plug-ins. This software is available for free at the National Instruments website and it is automatically downloaded on the first attempt to access the system.

Fig. 4 shows the system's login dialogue screen.

After inserting a valid login and password the session is started and the "Open VIs" button is enabled. Whether a session is finished by the user or by time out, the system becomes ready for another user's access.

The Fig. 5 displays the function generator and oscilloscope interfaces and it pops up when the button "*Open VIs*" is pressed.

The user can specify the desired parameters. The "*Enter*" button on the function generator stops the actual signal generation and starts it again with the new parameters. On

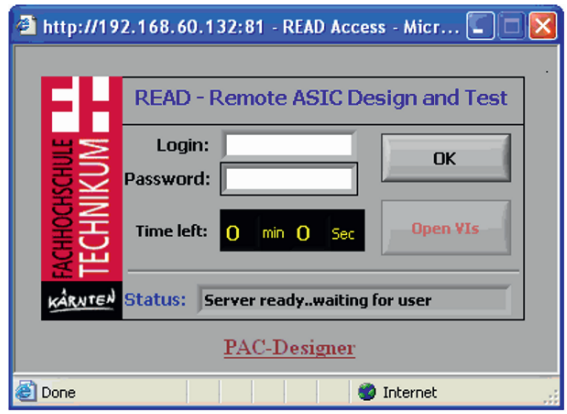


Fig. 4. Remote ASIC Design and test System dialogue screen

the oscilloscope panel, the "*Enter/Update*" button causes the new parameters to be sent and a new acquisition to be performed. It also consequently updates the oscilloscope screen with the new data and the "*function out*" field with a new measurement.

The fields *"Input connection"* and *"Connection node"* on the function generator and oscilloscope respectively specify to which input of the ispPAC10 the signal is applied and the pair input/output to be read.

E. The Citrix Server to Deliver the Application Software

As mentioned previously, one instance of the PAC-Designer software was installed on a Citrix Presentation Server, which is an end-to-end application delivery system that offers application virtualization and application streaming to enable the access for any user working over any network. The access to the PAC-Designer software is given by the link "PAC-Designer" below the access dialog screen showed in Fig. 4. The user has, therefore, full control over the application software, including downloading and

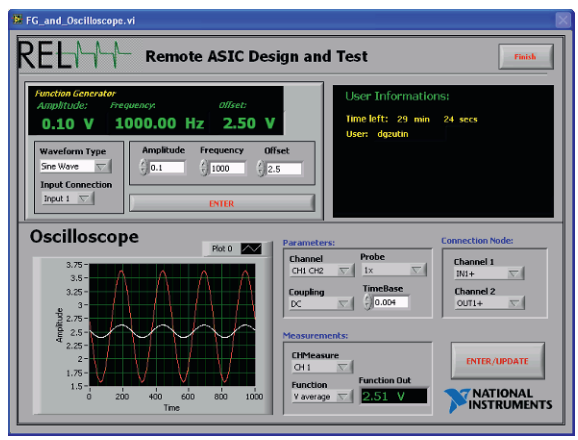


Fig. 5. Virtual Oscilloscope and Function Generator.

uploading schematics on the device. The server is connected to the circuit under test via the parallel port and the communication is based on the JTAG standard (IEEE 1149.1).

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III. Conclusions

Remote solutions can be an attractive tool as they offer a wide band of possibilities for applications in industries and e-learning. Remote systems can be very useful when applied to solutions involving high costs of people and equipment transportation. Different institutes and schools could share experiments and therefore knowledge in an additional manner. Also by using remote solutions it would be possible for universities with less financial resources to take advantages of expensive equipments from other institutions by means of a cooperative network of remote systems. The possibilities are huge and the future trends point to this direction.

The work presented with this paper shows one possibility for delivering remote control over one specific device (ispPAC10), but it should be taken as a solution that can be applied to other devices and systems.

The system cannot be considered as a replacement of related practical lessons, but a tool to bring practice in situations where laboratories cannot de fully assembled.

The project goals were achieved and the Remote Electronic Laboratory is working properly. The experiments with the ispPAC10 device could be performed in a satisfactory manner. Due to the hardware limitations (sampling rate of the DAQ card), the function generator could not generate signals within a large frequency interval. The hardware could generate signals up to 140 kHz, considering keeping a minimum of 20 samples per period in order to maintain a good quality of the signal and prevent aliasing.

The same problem was noticed with the input analog channel, once the DAQ sampling rate creates a limit for the maximum frequency that can be read without causing a misrepresentation of the signal.

In spite of that, the circuit behaviours could be well visualized for the performed exercises.

Different approaches can be used to deliver the access to remote users. A previous version of the system was implemented using ActiveX technology. A new ActiveX control was assembled with Visual Basic 6.0 using an ActiveX suit from National Instruments (Measurement Studio for Visual Basic 6.0).

Comparisons between different technologies show vantages and disadvantages of each one and therefore a second approach for the implementation of this system uses the solution with LabVIEW Runtime Engine and LabVIEW web server. The use of these tools makes the development much easier and faster, but on the other hand it is necessary that the user installs the proper version of LabVIEW Runtime Engine on his PC before accessing the system.

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mmeybodi@aut.ac.ir

Blogging from the Top: A Survey of Higher Education Leaders' Use of Web 2.0 Technologies

David C. Wyld
Southeastern Louisiana University
Department of Management - Box 10350
Hammond, LA 70402-0350 USA

Abstract – **This paper examines the rise of blogging amongst college and university presidents and other higher education officials in the United States and Canada. Due to its accessibility, blogging has become the foremost Web 2.0 technology. Blogging has now emerged as a new communications tool for both private and public sector executives. This is proving true in the college and university environment as well. While prior research has examined the use of blogging in college instruction and for disseminating thought and research, the present research is unique for its systematic look at the state of blogging by top college and university officials. While the research finds limited blogging amongst top academic officers at present, the projections are that this will grow exponentially in the future as blogs become more common. The paper concludes with a research agenda as more and more top higher education administrators look to enter the blogosphere as an important part of their official job functions.**

I. Introduction

We are certainly at an inflection point in the evolving history of the Internet. In December 2006, the editorial staff of *Time Magazine* named "You" as the "Person of the Year." The magazine recognized that the collective efforts of millions of individuals that were fast reshaping the Internet and the way we live our lives. *Time* recognized "you"- again meaning all of us- "for seizing the reins of the global media, for founding and framing the new digital democracy, for working for nothing and beating the pros at their own game" [1].

Whether it is termed by analysts as Web 2.0, user- or consumer-generated media or social networks, there is a vast sea change occurring, wherein the web has become a truly participatory media. The rise of what has been alternately referred to as consumer or user-generated media (content) has been hailed as being truly revolutionary in nature. Today, "anyone who can access the Internet can be part of the knowledge-access, knowledge-building, information-exchanging culture, regardless of location" [2].

Blogs are a fast-growing part of the wider social phenomenon of Web 2.0, representing the rise of a more accessible, interactive Internet. A blog can be simply defined in the following manner: "A blog is an easy-to-use content management tool. When you 'blog,' you are instantly adding new content to your site via a Web interface. No technical or programming skills are necessary" [3]. Blogs can be created using a variety of free or low-cost software and/or hosting services, such as those listed in Table 1.

TABLE 1
Major blog software/hosting providers

Service Provider	URL
Blogger	www.blogger.com
LiveJournal	www.livejournal.com
Moveable Type	www.sixapart.com/movabletype/
MSN Spaces	www.spaces.msn.com
Radio Userland	www.radio.userland.com
TypePad	www.typepad.com
Word Press	www.wordpress.org
Xanga	www.xanga.com

Blogging is fast-changing the way many of us interact with the Internet. In fact, blogging is now largely following the same development pattern as the Internet itself [4]. Whereas in the early days of the Internet, access was difficult and limited to academicians, researchers, government officials, and other elites, the rise of the World Wide Web and the development of browser technologies enabled the Internet to widen its audience and reach, while greatly changing- and perhaps even decreasing- the quality of the content and interactions online. With the wide availability of blog creation software tools and hosting services, no longer does one need specialized computer knowledge and resources to create content online. Indeed, blogs have been categorized as the rise of self-created web content. "Blogs are transforming the way Americans get information and think about important issues. It's a revolutionary change – and there's no turning back" [5].

Previous research has examined how blogging is being used to promote learning and communications with today's college students [6] and in fostering research dissemination and collaboration amongst university faculty [2]. In this chapter, we examine how and why blogging is taking hold amongst innovative college and university presidents. Through blogging, university leaders can better stay in-touch with their campuses and their stakeholders – and themselves. The research contains the first survey of college and university blogs, assessing the prevalence and focusing on several best practice examples. The author sets forth a research agenda on blogging in higher education and a look at how to assess the returns of blogging. The article concludes with a look ahead to the benefits and pitfalls of blogging for top college and university officials.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 106–111.
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mmeybodi@aut.ac.ir

II. College and University President Bloggers

In this project, the researcher sought to identify the current state of blogging amongst college and university presidents. As of October 2007, through intense Internet search, the author identified a total of twenty-four college and/or university presidents who currently have active blog sites. These are enumerated in Table 2.

TABLE 2
College and University Presidents with Blogs

Institution	President	Start Date
Arizona State University	Michael Crow	December 2005
Avila University	Ronald Slepitza	March 2007
Bethany College	Ed Leonard III	July 2007
Cambrian College	Sylvia Bernard	July 2007
Cedarville University (Iowa)	Bill Brown	September 2004
The College of Westchester	Karen Smith	March 2007
Colorado College	Dick Celeste	December 2005
Hendrix College	J. Timothy Cloyd	March 2007
Michigan State University	Lou Anna K. Simon	December 2004
Middlebury College	Ron Liebowitz	September 2007
Mohawk College of Applied Arts and Technology	MaryLynn West-Moynes	October 2006
Nicholls State University	Stephen T. Hulbert	August 2003
Ohio Dominican University	Jack Calareso	August 2006
Oregon Institute of Technology	Martha Anne Dow	May 2006
Pellissippi State Technical Community College	Allen Edwards	May 2006
Quest University	David Strangway	August 2006
Red River College	Jeff Zabudsky	October 2004
Southern Oregon University	Mary Cullinan	April 2007
Towson University	Robert Caret	February 2006
Trinity University (D.C.)	Patricia McGuire	September 2005
Trinity Western University	Jonathan Raymond	September 2007
University of Calgary	Harvey P. Weingarten	September 2007
University of Washington	Mark Emmert	June 2006
Wenatchee Valley College	Jim Richardson	August 2005

How successful have university presidents been as bloggers? Overall, a review of the twenty-four blogs identified through this research show that they have laregly been kept updated (new entries within the past month) and are well-presented. What was found amongst the blogs of these college and university officials was a wide variety of content, offering their views on both institutional issues and wider news events (such as the 2007 Virginia Tech mass shootings). They also blogged to publicize the successes of people and programs on their campuses. The presidents also used their blogs to serve as an open diary on their travels and other job duties, as well as opening a window to varying degrees - on their family life.

Presidential blogging has generally received positive responses from institutional stakeholders. Take the blog of President Bill Brown of Cedarville University for instance. A screenshot of President Brown's blog is provided in Figure 1. President Brown recently commented that: "It's (Blogging) been a very positive experience, and that's why I keep doing it. When I first started, I thought I'd have to come up with a treatise each time, but that's not what people want to read. They want to hear about my family, about what I'm doing, about what I'm thinking" [7]. Debbie Weil, a corporate blogging consultant, pointed out that: "Bill's blog is great! He's got just the right bloggy touch - informal, authentic, and an interesting glimpse into the thinking of a university president" [8] President Brown's blog is drawing positive responses from students and their parents as well. The parent of a Cedarville student recently commented that: "I am impressed at your joining the blog family. What an excellent way to know the hearts of your students" [7] Likewise, who could look at the blog of Towson University President Robert Caret and not get a sense of the man behind the office when he's hugging the school's mascot (as can be seen in Figure 2). Other best in class examples of presidential blogs are presented in Figures 3-7.

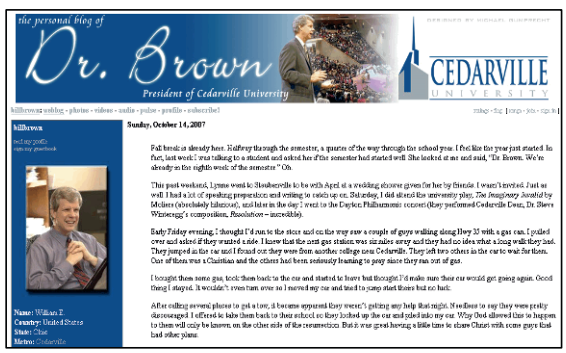


Fig. 1. Blog of Cedarville University President Bill Brown
(Available at http://www.xanga.com/billbrown)

III. Directions for Future Research

A. Blogging Research Overview

The evolution of the whole Web 2.0 phenomenon will be of intense research interest as it takes shape over the next decade. Specifically, as the blogging trend develops, there will be ample opportunities for research into how this phenomenon impacts a wide variety of communications and practices, across multiple environments. From an organizational communications and management perspective, there will be opportunities for research into how blogging impacts the effectiveness of both private and public sector executives in areas such as communications effectiveness and knowledge management. There will be specific opportunities for communications researchers to examine the use of blogging, both versus and in tandem with other means of communications, with audiences both internal to and outside

mmeybodi@aut.ac.ir



Fig. 2. Blog of Towson University President Robert Caret (Available at http://presidentcaret.org/blog/)



Fig. 3. Blog of Michigan State University President Lou Anna K. Simon (Available at http://president.msu.edu/desk/index.php)

of the organization.

Specifically in the realm of higher education, there will be opportunities to examine specifically how college and university presidents use blogs in ways both similar to and in contrast with executive leaders in for-profit and non-profit organizations. There will be opportunities to look at both the overall trends of the practice, and, through case study approaches, at best practice leaders and innovators. With university executives, there will be opportunities to examine the subjects about which they blog and the frequencies of their blogging activities, as well as the interest and feedback generated by such. Also, in both public and private enterprises, there will be opportunities to map and measure the viral nature of blogging, in order to understand how leaders in can influence others in their organizations to not only engage in blogging, but to make use of tools such as RSS (Really

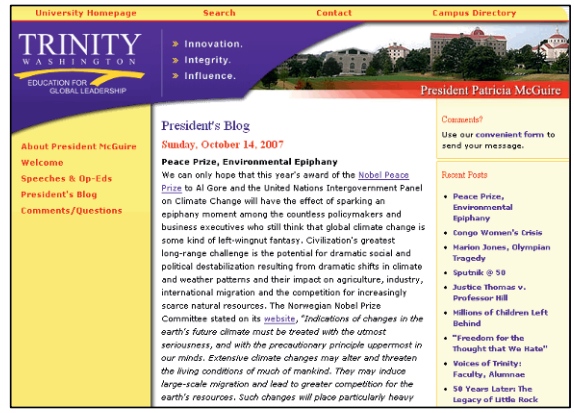


Fig. 4. Blog of Trinity University (D.C.) President Patricia McGuire (Available at http://www.trinitydc.edu/offices/president/blog/)



Fig. 5. Blog of Southern Oregon University President Mary Cullinan (Available at http://www.sou.edu/president/blog/)

Simple Syndication), podcasting, etc. We will thus be able to highlight and research instances where presidents and chancellors can engender a "culture of blogging" in their institutions' executive ranks, and research what the critical success factors are in doing so.

Finally, it has been predicted that best practices for organizational blogs will evolve over time [9]. This will be an area of intense interest, as there will be a ready audience for practical answers to the questions of highly-placed officials who will want to know how and why they should engage in this new medium. In short, as this is a communications practice and technology in its infancy, there will be vast opportunities for important and interesting research to be carried out over the next decade [10].

B. The ROI of Blogging

What is the ROI of blogging for executives in general, and for college and university presidents specifically? Even from a corporate perspective, blogging's return on investment is "less

mmeybodi@aut.ac.ir



Fig. 6. Blog of University of Calgary President Harvey P. Weingarten (Available at http://www.ucalgary.ca/news/blog/harvey)



Fig. 7. Blog of Red River College President Jeff Zabudsky (Available at http://www.rrc.mb.ca/index.php?pid=3898)

straightforward" than the ROI of traditional marketing techniques [11]. However, it has been demonstrated that a well-formatted, frequently updated and informative blog will: generate buzz and interest; encourage repeat visits to the blog and associated websites; and increase page ranks with the major search engines.

With blogging for college and university presidents, the ROI calculation can be even more indirect and incalculable. With a for-profit company, blogging can be seen as producing both direct, tangible results (i.e. increased traffic to corporate website, RSS and other subscriptions to updates of the site and the associated executive blog[s]) and making indirect improvements in corporate image and/or personal reputations, company/brand awareness, and even product sales/service utilization levels. With a non-profit organization, such as a university, many of the same visibility and awareness measures could be applied, with contributions/fund-raising and even student enrollment serving as proxies for sales results and institutional rankings by various agencies and magazines serving as proxies for reputation/awareness measures.

One can also use "on-blog" and "off-blog" metrics for assessing the amount of attention being garnered by the blog [12]. The former category includes the number of comments made on a specific blog post and the postings made on the blog's tagboard (which is a general space that is available for viewers to comment on the entire blog or website). Such off-blog metrics may include all mentions of the blog outside of the blog itself, including: news articles/stories regarding the blog in any media (or another blog or website); emails about the blog and/or forwarding of blog posts; and conversations about the blog. Certainly, blogs used by university administrators will have less defined ROI metrics, and discussions about ROI must always include "soft" aspects like: did blogging bring personal satisfaction to the official?; did blogging enable the official to get insightful comments and timely feedback from stakeholders?; and did blogging contribute to the official's decisions to remain (or retire) from his or her position? Insights on these soft metrics can really only be garnered through intensive surveys and/or interviews with the blogging university officials, with comparisons to be drawn with the non-blogging brethren in similar positions. Through such research, one could delineate the specific factors that may motivate an official to begin a blog, and conversely, the factors that may lead one to blog less frequently or to discontinue their blog entirely. Finally, we have recently seen the case of the British city of Ampthill, where the current mayor, Penny Foster, is continuing to blog, as did her direct predecessor, Mark Smith [10]. Thus, as such instances develop of "successor blogging," it will be interesting to investigate both the motivations behind the "new" university president or chancellor continuing the practice of his or her predecessor and the faculty/student/community expectations, reactions, etc.

C. Blogging Behavior Research

It will also be very interesting going forward to see very applied, analytical research to be conducted on the blogging behaviors of university officials. Such longitudinal research could examine the blogging behaviors of university presidents and other higher education officials in quantifiable terms, such as: the frequency of their posting activities; average number of days between posts; topics covered in posts (institutional, personal, travel, news and issues, etc.); comments allowed (yes/no) and number of comments; number of links to the blog posts of the official; amount (if any) of video/audio content posted; and official versus personal blogging activities. It would be interesting to then compare the blogging behaviors of college and university presidents between institutions on various dimensions (public versus private, institutional size and mission, geographic location, online versus traditional, etc.). One could develop many varied hypotheses that would seek to study the blogging behaviors of university officials on these institutional characteristics, as well as on personal and demographic characteristics.

mmeybodi@aut.ac.ir

Finally, over time, it will be interesting to compare both the penetration of blogging in general and the blogging behaviors/perceptions of university officials to comparable groups. As this is a global phenomenon, one can envision research projects comparing blogging between different countries (i.e., university presidents in the United States to those in various regions). One can also see projects that would compare the blogging penetration and blogging activities between top officials in the university environment versus other comparable groups in the public and private sectors. For instance, between university presidents and Fortune 500 CEOs, which group blogs more, who blogs more often, who uses trackbacks, pings, who responds to readers' comments, etc.?

As can be seen, many, many interesting studies on not just blogging, but the use of other Web 2.0 forums and tools, will likely – and need to be - conducted in the coming years. What will emerge from the work that will be done by university researchers, consulting firms, and independent researchers will be snapshots that will evolve into a mosaic of how these new tools are being used to foster better communication and new methods of engagement between top college and university officials and their stakeholders, who are themselves by and large increasingly living online lives. Such research will provide critical feedback for those making not only personal decisions on whether or not – and then how to – engage in blogging, but in setting blog strategies for both their institutions and themselves.

We will also see research on how blogs and other Web 2.0 tools are being increasingly integrated into organizational and university homepages, as the line will likely fast blur between what is a blog and what is a homepage. As the penetration of text/audio/video blogging elements increases, we may well see the distinction between blog and homepage disappear and become one site.

CONCLUSION

Like their counterparts in the private sector, blogging offers college presidents and other senior university administrators an unprecedented opportunity to communicate directly with their constituencies. In the higher education setting, this includes students, faculty and staff, alumni, prospective students, the community, public officials, etc. However, blogging offers unique benefits to the scholar, who is also an executive. Writing in *The Chronicle of Higher Education*, Rita Bornstein, the former president of Rollins College and the author of *Legitimacy in the Academic Presidency: From Entrance to Exit*, observed that: "From the moment new presidents are selected, their utterances and decisions are scrutinized for meaning, and they quickly learn to tailor their remarks to the expectations of different groups…After observing and studying successful presidents, I have concluded that, at every stage of their tenure, presidents who are aware of the challenges to their authenticity retain a clear-eyed view of who they are as individuals…and fight the temptations of self-importance and stay connected to their authentic selves" [13]. Blogging gives all academics a unique opportunity to do just that. In fact, it has been observed that: "Academic blogs offer the kind of intellectual excitement and engagement that attracted many scholars to the academic life in the first place, but which often get lost in the hustle…. Academic blogs also provide a carnival of ideas, a lively and exciting interchange of argument and debate that makes many scholarly conversations seem drab and desiccated in comparison. Over the next 10 years, blogs and bloglike forms of exchange are likely to transform how we think of ourselves as scholars. While blogging won't replace academic publishing, it builds a space for serious conversation around and between the more considered articles and monographs that we write" [14].

There are many legal issues to be considered as we see the growth of blogging in general and the rise of blogging amongst academic officers. Certainly, there are legal issues to be considered, as there have been several high profile cases already involving public and private sector bloggers who have run afoul of their employers for what they wrote in their blogs [10, 15] and executives who have been accused of making improper disclosures or misrepresentations on their blogs [16]. In the higher ed setting specifically, one's blog becomes a virtual paper trail that may indeed help or hinder one's success, as evidenced by the firestorm that erupted over Salisbury University President Janet Dudley-Eshbach's Facebook page, which contained photos and captions that many found objectionable and in poor taste [17]. Search committees are now routinely "Googling" applicants to determine which of them had blogs – and not considering those that did any further in the search process. Likewise, one legal scholar, Daniel Drezner, believes that his own well-known blog (which can be found at http://www.danieldrezner.com), may have indeed played a role in his being denied tenure at the University of Chicago [19]. Since blogging is such a new activity, there are very few standards or best practices to call upon, let alone intellectual protections for an activity that some academics frown upon due to the unfiltered, non peer-reviewed nature of the medium.

The one certainty is the need to be honest in one's blogging activities. As in the private sector [20], under no circumstances should a university president's blog be written by a school's public relations office or delegated to an assistant. As Steve Hayden, Vice Chairman of Ogilvy & Mather, the advertising giant that is now advising its corporate clients on blogging, recently remarked: "If you fudge or lie on a blog, you are biting the karmic weenie. The negative reaction will be so great that, whatever your intention was, it will be overwhelmed and crushed like a bug. You're fighting with very powerful forces because it's real people's opinions" [21].

Over time, blogging college and university presidents will likely become normal, if not "the norm," and as with their private sector top executive counterparts, this will be an area ripe for practical advice and research as higher education administrators learn to thrive – both professionally and personally – in a "carnival of ideas."

mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

NP-Hard Graph Problems' Algorithms Testing Guidelines: Artificial Intelligence Principles and Testing as a Service

Deniss Kumlander
Department of Informatics, Tallinn University of Technology,
Raja St.15, 12617 Tallinn,
Estonia
kumlander@gmail.com

***Abstract*- There is a permanent great interest in developing fast exact algorithms solving NP-hard problems like finding the maximum clique, a vertex coloring and so forth. The testing step is an essential one in the process of inventing new algorithms and can generate a lot of valuable information if it is built and used appropriately. The paper proposes methods and functionalities that should be included into the testing tool. The high level idea is to use the testing process as a service for the algorithms construction process by providing necessary feedback, i.e. have a concurrent cycle between the algorithm (mathematical) production phase and the testing phase. Thereafter the paper discusses what kind artificial intelligence can be implemented into such testing tool to increase the quality of results and vice versa - what the testing tool can produce for the artificial intelligence algorithms targeted to solve NP-hard problems.**

I. Introduction

Let $G=(V,E)$ be an undirected graph, where V is the set of vertices and E is the set of edges. Two vertices are called to be *adjacent* if they are connected by an edge. A *clique* is a complete subgraph of G, i.e. one whose vertices are pairwise adjacent. An *independent set* is a set of vertices that are pairwise nonadjacent. A *complement graph* is an undirected graph $\hat{G}=(V,\hat{E})$, where $\hat{E} = \{ (v_i , v_j) \mid v_i , v_j \in V, i \neq j, (v_i , v_j) \notin E \}$ – this is a slightly reformulated definition provided by Bomze et al 1999 [1]. A neighbourhood of a vertex v_i is defined as a set of vertices, which are connected to this vertex, i.e. $N(v_i) = \{v_1, \ldots, v_k \mid \forall j: v_j \in V, i \neq j, (v_i , v_j) \in E \}$. A *maximal clique* is a clique that is not a proper subset of any other clique, in other words this clique doesn't belong to any other clique. The same can be stated about maximal independent set [1, 2, 3].

The maximum clique problem is a problem of finding maximum complete subgraph of G, i.e. maximum set of vertices from G that are pairwise adjacent. In other words the maximum clique is the largest maximal clique. It is also said that the maximum clique is a maximal clique that has the maximal cardinality. The maximum independent set problem is a problem of finding the maximum set of vertices that are pairways nonadjacent. In other words, none of vertices belonging to this maximum set is connected to any other vertex of this set. A graph-coloring problem or a coloring of G is defined to be an assignment of colors to the graph's vertices so that no pair of adjacent vertices shares identical colors. So, all vertices, which are colored by the same color, are nothing more than an independent set, although it is not always maximal. The chromatic number - $\chi(G)$ is the minimum number of colors needed for a coloring of G [1, 3, 4, 5].

The same problems can be stated for weighted graphs, i.e. for an undirected graph $G=(V,E,W)$, where V is the set of vertices, E is the set of edges and W is the set of weight of vertices from V (each vertex has one and only one weight). In this case, the maximum clique problem transforms into the maximum weighted clique (or the maximum-weight clique) problem asking to find a clique of the maximum weight [1], i.e. where sum of vertices' weights belonging to the clique is maximum for the graph. It is also possible to formulate the same problems with weighted edges [6].

All those problems are NP-hard on general graphs [7] and no polynomial time algorithms are expected to be found. There are also so called "heuristic algorithms" allowing finding a solution of a problem in a polynomial time without any guarantee that the found solution is the maximum / best one. Those algorithms are widely used both as a possible way to solve problems during a reasonable time and as subtasks of exact algorithms, for example for finding boundaries [6].

There is a great interest in developing fast exact algorithms solving those NP-hard problems on graphs' instances with a reasonable number of vertices since it can be used in many important practical applications. Examples are efficient register allocation [8], on-line bin-stretching [9], scheduling of parallel jobs [10] and a lot of others including applying artificial intelligence logic [11]. The reasonable number of vertices refers to the fact that we are about to explore in this article only questions related to practical algorithms and graph instances (i.e. where the problem can be solved during a feasible time frame) rather than talking about sophisticated mathematical concepts that will never turn into algorithms in use. In other words there is no points to get consider algorithms that behaves generally well on a very large number of vertices, but

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preliminary checks will require, lets say, a year to produce a result.

One more definition is needed before guidelines will be presented to abstract the topic to many kinds of NP-hard problems. Let's say that a size of a solution (for an NP-hard problem) is a number of elements that are included into it, where the "element" is the primary optimization goal. For example in the vertex coloring problem a color is element as the optimization goal is to minimize the total number of colors used to color a graph. So the size of the solution will be the number of colors we do need to accomplish the task. The maximum clique problem asks to maximize the number of vertices included into the maximum clique, so elements are vertices (which are connected to each other and form the maximum clique).

Although the testing process is sometimes not considered by algorithms' inventors as an important step, it is still an essential one from our point of view. It is not enough to come up with a mathematical concept. It should be both verified (correctness) and proved to be worth to use. It is easy to fail during the testing step, for example serving incorrect cases to the algorithm, and conclude that the algorithm is bad although it is not. Therefore full attention should be paid to this final step. Moreover we do propose in this article using the testing step as a service during the algorithm invention process rather than consider it as just the final step. In other words it should be integrated into the invention cycle rather than terminate it. The other important contribution of the paper is an idea to use artificial intelligence to increase quality of the testing process and use the testing process to derive rules to be used for artificial intelligence algorithms for solving those NP-hard problems.

The paper is organized as follows. The second chapter discusses the testing process providing guidelines on constructing the testing tool, formulates best practices and comes up with a "testing as a service" idea. The following chapter discusses artificial intelligence principles applied for testing and vice versa. The forth chapter concludes the paper.

The article continues a discussion started by Johnson in 2002 [12] and Kumlander in 2007 [22].

II. Testing Process

A. *"A" Task: Testing*

The most basic testing target is to verify that an algorithm to be tested works correctly. The correctness of an algorithm is usually measured by two properties:

- Whether it hangs or raises any run-time errors;
- Whether it does produce a correct result.

There are two primary ways to test algorithms on correctness in the NP-hard problems' area. The first one is to use well-known examples for which answers are known. Those examples can be produced in-house or been fetched from other sources. For example there is a package of different graph types that were used in so called "Second DIMACS Challenge" for the maximum clique algorithms' competition [14]. The second way is to conduct a comparative test using as a benchmark other well-known algorithms and compare results. The comparative test can be an option to go with for the initial testing, if there are already implemented (earlier) algorithms, as it can be easily automated within the testing environment and allows producing much more information. Otherwise the first alternative should be used, which has an obvious restriction on number of cases available for using.

Notice that sometimes it is hard to say whether the process went into an endless loop or still solving the case since we deal here with NP-hard problems.

B. *"B1" Task: Exploring - comparing*

Many testing environments do restrict themselves with the earlier described task. Some others do several other basic steps to be described under the "explore" task, but do explicitly identify it as a special sub-task that should be planned, implemented and monitored loosing some important details. The "exploring" task is a task to analyze the algorithm to be tested by collecting some extra data about it. It is very interesting and challenging task that can be accomplished in different ways and therefore contains a lot of sub-procedures. Therefore we will discuss the "explore" task underneath by splitting it into sub-targets.

The first target can be to find whether the algorithm is acceptable or putting it in other way - worth to have. As with any approaches solving a problem, there are different ways (algorithms) to solve a particular problem producing the same results but varying in ways the result is achieved. It is possible that different algorithms have different advantages and disadvantages and it is possible that some of them are just more complex (from the implementation point of view) or more "expensive" (from the resources point of view). Consider for example different algorithms for finding Fibonacci numbers (sequence), where the first algorithm for example uses a recursion and the second one uses an extra memory array to remember numbers produced during the internal calculation for each sequence position. It is clear that the second algorithm does demand more memory, but the first one will be really much slower to produce an answer, so the memory disadvantage is not worth to be discussed especially if you don't have any problems with it. In that case the first algorithm is not worth to have as it is more expensive from the spent time point of view (resources) producing no real benefits in compare with others (the other). The same can occur with any algorithm for the NP-hard problems, but the difference from the time-complexity point of view will be much more remarkable. Concluding all previously said, the exploring task target is to find whether there are any graph cases (randomly generated or special graphs) where the new/tested algorithm is better than any of well-known algorithms. If the tested algorithm is always slower then the tester (test program) can conclude that the testing "failed" for that algorithm or returned

mmeybodi@aut.ac.ir

a negative result as the algorithm is useless. So the first exploring task is achieved via comparing the target algorithm with other well-known algorithms in order to find whether it is good in achieving its primary goal.

Notice that even if an algorithm fails on this phase there could be some reasons to do other exploring researches described below in order to find whether the implemented idea is useless or there are some hopes to tune that.

C. "B2" Task: Exploring - analysis

The next task of the exploring step of the testing process can be to capture the tested algorithm work characteristics (parameters) in order to analyze them later. The ultimate goal here is to produce enough details to understand why the algorithm is the quickest or the slowest one, why it managed to solve all or just some cases successfully and what cases produced troubles for the tested algorithm.

It is possible to divide captured parameters on internal and external by the level of access to the algorithm "box" required to produce those.

The internal parameters can be captured only if you:

- Have source code of algorithms
- Know the logic of algorithm

The first one let you to pre-process the algorithm source by adding into its code necessary debugging commands (information collectors). The second one ensures that the tester is able to do that correctly and identically for all algorithms in case a comparative test is conducted. The parameters to capture are normally specific for algorithms and can be: a number of analyzed branches, a number of used colors, the lowest and the highest bound of start solution and so forth.

The external parameters are characteristics that can be captured without modifying the algorithm source code. In other words the algorithm is seen here as a "black box". The most important one of course is the spent time as algorithms time complexity is a primary goal for inventing new algorithms in the NP-hard problems area. Each new algorithm tries to decrease this parameter. The next parameter is used memory as for very large graphs the swapping can arise as a real issue affecting the overall (time) performance.

Algorithm work characteristics' details give an overview on how the algorithm behaves on different cases, why it was slow or fast (if the collected information is sufficient to see what made those examples so special). The more interesting analysis can be made if the same characteristics have been captured for several algorithms during the simultaneous (comparative) test.

Note: a simultaneous test is a test when the same (graph) cases as served to different algorithms asking to produce a solution.

Comparison of those parameters will show why one or another algorithm is the fastest or slowest on certain graphs, give a clear picture on graph types where the tested algorithm was the best and let to guess what other similar types can be (so the algorithm become the best one on a set of certain graph types). It will also give enough information to conclude whether it is possible to tune the algorithm to eliminate its weaknesses (at least as much as possible). Notice that those modifications can potentially lead to producing a range of algorithms - each algorithm will be suitable only for certain graph type, but those will be derived from the same base. This situation moves us to the next testing functionality, which is exploring and clustering.

D. "C" Task: Exploring or Clustering

Details that are produced during the test process are normally sufficient to divide existing algorithms by graph types to which those suit best. It is obvious that there is no universal algorithm at the moment, which will be the best on whatever type of cases (graphs). Generally we can say that there are general algorithms, which are able to solve any graph, and special algorithms that are designed for special graph types. Consider for example algorithms for permutation graphs and perfect graphs [15, 16]. Moreover, general algorithms are not working similarly on different case of the same major type – for example it is possible to distinguish, which algorithm is the best on dense graphs and which is the best on low density graphs [6, 17, 18].

Ideally the testing tool would produce a mapping between algorithms and graph types, i.e. identify an algorithm that is the best for using on that graph case. Graphs can be clustered by densities, source of graphs or types of graph (if such information is available) and so forth [19].

Note: unfortunately the analysis of graphs in order to derive its structure and identify the type is a very complex problem, so we cannot propose including this functionality into the testing tool, but the testing tool can be the best place to have it as we need to identify a graph type the algorithm is best once testing that and later apply this knowledge.

The algorithms clustering mapping can serve as a base to build either static artificial intelligence into NP-hard problems' solving algorithms or be a starting point of adaptable algorithms. This is discussed more under the "Artificial Intelligence from Testing" chapter below, but the generated mapping is by itself important information for algorithms authors.

E. Special cases: Incomplete solution

Finally we would like to mention that the ultimate test package should be exploring special cases as well. Beyond special graphs there are other specific parameters affecting algorithms performance.

Consider for example real-time systems. It is a type of systems where a solution should be provided during a restricted amount of time. A lot of important applications are hosted in such environments like for example faults diagnostic or pattern recognition, which are used in even more important areas like for example the health care. Unfortunately NP-hard problems are time-complex problems, i.e. their complexity is

mmeybodi@aut.ac.ir

none deterministically polynomial. So, there is a "time" resource conflict between an amount of time that the real-time system can allow and a time that NP-hard problems require to have in order to produce a solution. There are some articles on this case, which could give general ideas on what should be done to research that environment [20].

F. Testing as a service

So we do propose to see the testing process not only as a verification of whether the algorithm does work correctly, but also as a service to understand algorithms and produce new. The testing service should break out from the verification target and be included into the algorithms invention process as other steps like for example the mathematical analysis.

Moreover it can be implemented as a web service providing a common base for testing all algorithms concentrating inside one web host all information about different algorithms, cases, mappings and so forth. Of course it needs standardization of the interface and (probably) an agreement on algorithms' implementation techniques to ensure that those can be correctly called from the testing routine and have the same programming language to avoid differences of results produced by any other factors than the algorithms' structure.

III. Artificial Intelligence and Testing

A. Artificial Intelligence for Testing

A lot of manual work is required to find out what tests cases can be served for algorithms to be tested. Unlike many standard testing tasks, the NP-hard problems have an important property making them special: the time complexity as we mentioned several times above. It means (with certain approximation of complexity theory, which is not the major subject of this paper) that time required to solve a case grows exponentially with increasing the number of element (for example vertices talking about the graphs size). In other words it is not possible to test the algorithm on all possible graph cases. There is only a certain range of cases available for testing. Notice that too small number of vertices is also acceptable as exploring the algorithm becomes impossible since the time measure routine has too big standard deviation in that case, although the verification process is still possible. Summarizing all said above, the task is to find an appropriate number of vertices to generate graph cases for the testing process so that the time needed to solve it will be appropriate (usually no more than a day and no less that 3 seconds). There are several methods for finding the right number of vertices, which vary by its sophistication. The most elementary one is "do it manually", i.e. to run tests and increase the number of vertices from a predefined low level to an appropriate one. The second method will be to automate this process, so the computer will tune this parameter and collect much more statistic by running the tested algorithm(s) on more cases than a person can do manually. The last method will be to find the number in a more intelligent way. If the second method was increasing the number "mechanically" then the intelligent system would:

- *search for patterns and build a function of time complexity depending on the number of vertices for all densities;*
- record suspicious places
  a. if the time complexity function suddenly changes (un-monotonously) then this particular range should be explored with a smaller step of vertices' number increase;
  b. record graph cases that were resolved either very fast or very slowly hoping to obtain from those cases additional information later;
  c. compress results: it is possible to return an individual number for each density/number of vertices that were tested, but if a parameter changes monotonously then it is better to produce a result only on some key points;

Another possible artificial intelligence application place is the graph cases generation routine. It is common to produce randomly generated graphs for the testing. The randomization process should surely avoid producing similar graphs as otherwise results will not be reportable for a general case of random graphs. The graph generation program can be not only free from such errors, but vice versa - we can call it to be in a special mode: try to produce different special cases in order to produce more specific details. The more such specific details we collect the more information on an algorithm weaknesses and strengths will be obtained for later analysis.

The real intelligence comes to the testing when the following requirement is defined: the testing core should be able to adapt to the tested algorithms. What we are looking for is an intelligence that can explore algorithms by itself highlighting the most interesting aspects of it (characteristics, cases etc). Moreover it should contain information about best known algorithms or their characteristics in order to provide comparative tests' results, process those, analyze and come up with hypotheses or proved conclusions. What are specific cases where the algorithm is especially good or bad and what is the reason? Keep the track of graph cases hard to solve and alert if the new algorithm was able to perform on those graphs quite well or better than others and so forth.

B. Artificial Intelligence from Testing

The generation of a mapping between algorithms and graph cases has been mentioned above under the testing chapter and produced a rule finding for each graph case (cluster) the best algorithm to be used. It is essential information that can be used to build an artificial intelligence meta-algorithm to solve the dedicated NP-hard problem. The meta-algorithm does include a set of algorithms solving this particular NP-hard problem and the mapping, so the "right" algorithm will be selected (run) for each case to be solved. The mapping can be

mmeybodi@aut.ac.ir

constructed by an intelligence built into the testing rule and be an output of the testing step. It can be used as is for a static meta-algorithm or serve as a starting mapping for algorithm that could adapt for the particular environment by doing extra steps and changing the mapping during it work process. Anyway the using of such mapping can improve the performance of the NP-hard problems algorithms as it was demonstrated in some previous works [19, 21, 22].

IV. Conclusion

The author conversations in conferences halls with colleagues and own experience have demonstrated that the process of testing new algorithms have been able to produce a lot of surprises to their authors. It mainly happens since the testing wasn't carefully planned, implemented or doesn't report correct figures. Therefore we should pay much more attention to this area especially in such area as NP-hard problems, where each mistake could have a combinatorial effect. Moreover the testing can be a crucial step of inventing new algorithms as the collected details is a very valuable feedback moving the algorithms analysis process greatly forward. The testing should not restrict with the verification process, but should also explore algorithms, hopefully using artificial intelligence principles rather than doing it mechanically. The testing tool should also process testing results decreasing the amount of returned information. Finally it should be converted into an intelligent service giving us no less information than mathematical analysis of algorithmic structures.

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mmeybodi@aut.ac.ir

Pattern-Based Usability Evaluation of E-Learning Systems

Dmitry Zub, Erki Eessaar
Department of Informatics, Tallinn University of Technology, Raja 15, 12618 Tallinn, ESTONIA
dmitri.zub@mail.ee, eessaar@staff.ttu.ee

***Abstract*-Each pattern describes widely used and generally accepted solution to a recurring problem. In this paper, we propose a novel pattern-based usability evaluation method. It uses Analytic Hierarchy Process (AHP) in order to achieve numerical results based on evaluations of different systems and make this evaluation as objective as possible. We also present results of a case study about usability of several e-learning systems.**

I. Introduction

This work has two main themes: e-learning and usability. E-learning is one kind of distance learning. Distance learning can be described as "education that takes place independent of location, in contrast to education delivered solely in the classroom and that may be independent of time as well."[1] This is achieved by the fact that the learning material is delivered via different means of instruction. At first it was mail correspondence then radio, TV, CD-ROM discs. The next stage of this evolution is web-based delivery of the learning materials. E-learning itself can be defined as "a wide set of applications and processes, such as web-based learning, computer based learning, virtual classrooms and digital collaboration." [2] The delivery of this material goes through Internet, audio- and videotape and other means.

Systems that have been in our area of interest are web-based learning management systems. Some of the main functions of those systems are creating courses, registering students, tracking progress of students and assignments. But apart from functionality of e-learning systems there is another significant issue. The system should be quite easy to use so that the potential students will not spend too much time in order to find out how to use the different functions of the system.

The first *goal* of this paper is to present a novel usability evaluation method. It was initially developed in attempt to evaluate the usability of some well-known international e-learning systems in comparison with the e-learning system *Maurus* that is created in Tallinn University of Technology (TUT). The second *goal* is to present the results of this evaluation.

In this study, we use *action research* methodology [3] that requires active participation of investigators in the practice. The process of the action research consists of potentially unlimited number of iterations of building of theory and practicing it. Theory (in this case usability evaluation) is a structure emerging from practice. It should be continuously controlled and improved by the practice. In this paper, we propose a usability evaluation method (theory) that has emerged from the usability evaluation of e-learning systems (practice).

The organization of this paper is as follows. In section II we give an overview of some usability terms. The following section describes shortly the Analytic Hierarchy Process (AHP), which allows us to analyze systems and compare them between each other. Patterns are the criteria that are used in the proposed usability evaluation method. Therefore, section IV gives an overview of the main principles of patterns. The next section gives an overview of some existing usability evaluation methods. Next, we present the results of a usability evaluation of some e-learning systems. Firstly, we explain for what reason patterns are selected as criteria for usability evaluation. Secondly, the patterns used for our analysis are described. Thirdly, the results of usability evaluation that was performed in our study are presented. In section VII the general method for usability evaluation is described. Next, we describe further development of the method. Finally, we draw some conclusions.

II. Usability

Researchers have proposed many overlapping definitions of usability [4]. For instance, ISO 9126 [5] defines software usability as "the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions". As you can see, this definition refers to different aspects that must be considered in the context of usability. Folmer and Bosch [4] give an overview of different proposals of these aspects. Some of the most recurring of them are following:

Ease of learning – How fast can a user, who has not seen a user interface before, learn this interface so that he/she can accomplish basic tasks?

Efficiency of use – Once an experienced user has learned to use a system, how fast can he/she accomplish tasks?

Memorability – If a user has used a system before, then can he/she remember enough to use it effectively after some time has passed or does the user has to start learning from scratch?

Error frequency and severity – How often do users make errors while using a system, how serious are these errors, and how do users recover from those errors?

Subjective satisfaction – how much does the user like a system?

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 117–122.
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In this paper, we propose that for the analysis of the usability of systems (including e-learning systems) we can use Analytic Hierarchy Process and patterns. Therefore, in the next sections we shortly introduce these concepts.

III. Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) [6] allows us to make decisions by modeling a complex problem in a hierarchical structure. The levels of this model, if we begin from the upper level, are:

Goal – overall objective. The goal is connected to some kind of choice. For example, "Find the best e-learning system in terms of usability".

Objectives – What are we trying to achieve while choosing between e-learning systems? What are the main criteria that we should take into account while making our choice? For example, the usability aspects could be used (in theory at least) while evaluating e-learning systems.

Alternatives – Objects between which the choice will be made. In our case the objects are e-learning systems that we will analyze.

The next step after model building is to compare the elements. Firstly, we should compare objectives in order to find their importance for achieving our goal. After that we should compare how well do the alternatives correspond to each objective.

AHP uses pairwise comparisons in order to make evaluation process easier to a human expert who must perform the evaluation. Elements of the same level (goals, objectives, or alternatives) are compared with each other in respect to one element of higher level in a single matrix. The scale for comparing the elements is presented in Table I.

After all the comparisons are made, the geometric mean of comparison grades is calculated for each compared element, and the weight of each element is calculated so, that the sum of the weights is equal to 1. After combining all the weights, the final evaluation values for alternatives are found.

IV. Patterns

The idea of patterns was firstly used in the context of civil architecture [7]. Later patterns became popular in other areas like object-oriented software design [8], specification of databases [9], design of user interfaces [10, 11] and pedagogy [12, 13].

Every pattern describes a solution to some kind of recurring problem. The use of patterns helps us to prevent inventions of the solutions over and over again.

TABLE I
Comparison scale of the AHP

Numerical value	Verbal scale of importance
1	Equal
3	Moderate
5	Strong
7	Very strong
9	Extreme
2, 4, 6, 8	Used to compromise between two judgments

Instead it allows us to concentrate on the accumulation of new knowledge. There are different formats that can be used in order to specify a pattern. However, generally the name of a pattern has some kind of a hint on how to solve the problem. The body of the pattern consists of at least three main parts. Firstly the *context* (background or situation) where this pattern can be used is described. Then the *problem* that appears in that context is described. The final part is a *solution* of the problem together with discussion on how to implement the solution.

V. Methods of Usability Evaluation

In this section, we shortly describe the best-known usability evaluation methods. There are a lot of methods of usability evaluation. These methods can be divided into several categories, the best known of which are usability inspection [14, 15] and usability testing [15].

Usability inspection is the process of evaluating the system by experts in design, usability and other relevant fields but without participation of the potential end users of this system. In usability testing the users are given some specific tasks to accomplish and their actions are recorded in some way. In addition, users could give a feedback on how easy or hard was to accomplish the tasks.

Some usability inspection methods specify some actions that are similar to the actions of the proposed approach. These methods are shortly described below [15, 16, 17]:

Heuristic evaluation – usability experts judge whether the elements, features, or functions of a system follow certain usability principles that are called heuristics.

Cognitive walkthrough – a technique where firstly the task scenarios are created and then played through by usability experts. The experts must pay attention to the possible problems that potential user could have while accomplishing the task.

Formal usability inspection – is a procedure with strictly defined roles and actions. It combines the first two above-mentioned methods.

Feature inspection – it is used for checking a set of features that are used for accomplishing some usual task (e.g. to submit a solution to an exercise).

Consistency inspection – here designers from other related projects (e.g. some products in a set of software) check if a system acts the same way as their projects.

S*tandards inspection* – it is used for checking a system against the established standards (rules) that are accepted in this area.

VI. Usability Evaluation of e-Learning Systems

In this section, we describe the results of the usability evaluation of a set of e-learning systems. The general idea of the approach is that we compare a system that is under evaluation with other similar systems in terms of patterns by using AHP. We use *usability* and *e-learning* patterns as

mmeybodi@aut.ac.ir

criteria in order to perform AHP. We present generalized specification of the approach in section VII.

A. The Choice of Criteria of AHP

As it was mentioned in section III, AHP allows us to make choice between some alternatives. The result depends on information about what alternatives correspond better to the selected criteria. Therefore, we should pick some criteria in order to use AHP. Two main alternatives were considered while choosing the criteria. One alternative was to use usability factors (ease of learning, efficiency of use etc. – see section II). The second alternative was to use the usability patterns. The disadvantage of usability factors is that they are very abstract. For instance, it is quite hard to evaluate whether one system is easier for learning than some other system. The patterns on the contrary are more specific and it is easier to make evaluation based on them. Another advantage is that the patterns are so specific that they may be used as guidelines that help designers to fix usability problems. Therefore, it was decided to use web usability patterns [11] for judging usability with the help of AHP. In addition, we decided to use some domain-specific patterns about e-learning [13].

The idea of using patterns in the context of usability evaluation is not completely new. Schmetow [14] describes an approach that uses usability-patterns as heuristics in the heuristic evaluation method. The approach that is proposed in this paper uses additionally domain-specific patterns (e-learning patterns). Folmer et al. [18] propose to use patterns in order to create a software architecture that supports usability. However, we do not know a method or a system that uses patterns as the criteria for usability evaluation and combines them with AHP.

B. The Selected Patterns

Below is the list of the selected patterns together with short explanation. We also show initialisms of these patterns that we use in Table II. In this research, we did not use any formal method to select the set of patterns from the set of all possible patterns. We made the selection based on our experience. In our view these patterns represent the main principles of usability.

Web Usability patterns were:

Two Years Old Browser (2YB) – A user who has somewhat outdated software or hardware should be able to use the system.

Site-map (SM) – There should be a possibility to see the site structure in order to find the necessary information as quickly as possible.

Feedback (F) – A user should get a feedback whether his/her actions were successful or not. If an action failed, then the system should specify what went wrong.

Sense of location (SL) – A user should see in what part of a website or a system he/she is. Also, when some complex process is executed, it would be good to know what steps are already done and what are yet to be completed.

Follow standards (FS) – The user has his/her own experience of working with similar web sites and therefore well-known traditions and rules must be followed. That makes the system easier to learn.

We decided to use the following e-learning patterns:

Interactive elements (IE) – Set of learning activities should be implemented in e-learning system. They should enable active participation and interaction between students and teachers.

Project based e-learning (PBL) – E-learning system should have the tools that make project-based learning more effective. Examples of these tools are project proposal, market, or diary. This pattern was selected because project-based learning is quite popular (it is also actively used in our university) and has been shown to produce good results [19].

Collect feedback (CF) – A system should allow teachers to collect feedback about the course or the use of the software. It will help a teacher to improve the course. Feedback about using the system will be also useful for usability evaluation.

Team workspace (TW) – Projects are usually made in groups. Therefore, each team should have their own space for storing their joint work.

Computer-mediated communication (CMC) – In e-learning one of the most important ways of getting the information is to communicate with teacher and fellow students. The tools for that should be provided by the system.

C. The Alternatives

One of the practical goals of the project was to assess the usability of one of the e-learning systems of the Tallinn University of Technology called *Maurus*. It is one of several systems that have been created by university staff, in order to achieve flexible and easily manageable e-learning system. It is used in the courses about database and information-system design. It is a learning management system that allows lecturers to create a course, distribute learning materials and references to interesting web-pages, post messages to a message-board, publish exercises and collect their answers and organize registration of students to the exams.

Along with this system, the following international e-learning systems were evaluated in the analysis: Claroline, FLE3, OLAT. This set of three systems was chosen for the following reasons. Firstly, all of them are open source systems. This approach has some advantages. University staff has possibility to extend and improve open-source systems, if necessary. In addition, it is much easier compared to commercial systems to get access to these systems and start the testing. Second requirement is that the systems should have at least the same features as *Maurus*.

The *Claroline* project was initiated in 2000 at the Catholic University of Louvain (Belgium) by Thomas De Praetere [20]. It has some course management capabilities like for example holding courses, providing documents and links, and participation in forums. One feature of the system that looks special is the possibility to create a wiki for the course. Wiki

mmeybodi@aut.ac.ir

[21] is the group of web pages that users can create and edit like if it was a forum.

FLE3 (Future Learning Environment) is developed by Learning Environments for Progressive Inquiry Research Group UIAH Media Lab, University of Art and Design Helsinki [22]. This system is not typical course management system. It is a web-based learning environment. This is created for computer supported collaborative learning [19]. It contains special learning tools like *WebTops*, *Knowledge building,* and *Jamming*. For example, *Jamming* provides a shared space for collaborative creation of digital content (pictures, text, audio, and video).

OLAT (Online Learning And Training) is a web-based Open Source Learning Management System (LMS) / Learning Content Management System (LCMS). The initial development started at the University of Zurich, Switzerland [23]. It is a course management system with some interesting differences. For example, a student there does not register for a course but enrolls learning group. After that courses are assigned to particular learning groups.

D. The Results

The analysis was performed by *one* usability expert.

Step 1: We compared the types of patterns (web usability and e-learning) and found the weights of pattern types.

Step 2: In case of each pattern type, we compared the patterns of that type between each other and found the initial weights of patterns.

Step 3: We compared 4 e-learning systems in terms of every single selected pattern and found the initial weights of systems. The results are in the rows "Maurus", "Claroline", "FLE", and "OLAT" in Table II.

Step 4: We multiplied the weight of each pattern (from step 2) by the weight of its corresponding pattern-type (from step 1). The results are in the row "Pattern Weight" in Table II.

Step 5: The final weight of each system (alternative) was calculated by using (1).

$$p_1*s_1 + p_2*s_2 + ..+p_i*s_i.. + p_n*s_n. \quad (1)$$

In this case, n denotes the amount of patterns (criteria). p_i denotes the final weight of i-th pattern (from step 4). s_i denotes the weight that the system received in the comparison matrix related to i-th pattern (from step 3). The final weight of each system is presented in the column "Sum" in Table II.

The usability expert decided that the level of importance of e-learning patterns is *moderately* bigger (see Table I) compared to the usability patterns. According to the analysis, FLE system is the best system in the set of selected systems in terms of conformance to the e-learning systems. Therefore, FLE system has the highest score. Next two systems have virtually even score. They both have many interesting and useful features. However, *Claroline* has a bit higher score since it is more traditional in its design and it is easier to learn in our opinion. *Maurus* system has the lowest score because it is not so feature-rich and it has some usability problems. The practical result of this study was a set of recommendations for improving the usability of the *Maurus* system. The results also show that in-house development of an e-learning platform, instead of using an open-source system, has not yet lead us to the best possible results.

VII. General Method of Analysis

In this section, we propose a novel method for performing usability evaluation of a system. It is created as a *generalization* based on the study of usability evaluation (see the previous section). It allows usability experts to repeat this process in order to perform usability evaluation of other systems. That process consists of 8 steps:

1. Selection of systems (alternatives) and patterns (criteria) for the evaluation.
2. Analysis of the patterns that are selected for the evaluation.
3. Writing of specification of tasks and evaluation based on these tasks.
4. Analysis of the results of tests.
5. Calculation of the final weights for every system.
6. Identification and solving of the main problems that were discovered during the testing.
7. Retest of the system.
8. Analysis of patterns.

Next, every step of this method will be described and discussed in more detail.

Step 1: Selection of systems and patterns. If a system (that is analyzed) is under development, then it would be useful to study similar systems. If a system already exists, then it is still important to find out what possible improvements we can make in the system. In addition, it is valuable to know the opinion of future users of the system (teachers and students in case of e-learning systems).

TABLE II
Weights of Patterns and E-learning systems

	2YB	SM	F	SL	FS	IE	PBL	CF	TW	CMC	Sum
Pattern Weight	*0,013*	*0,028*	*0,098*	*0,037*	*0,074*	*0,328*	*0,153*	*0,046*	*0,099*	*0,123*	
Maurus	0,391	0,060	0,067	0,066	0,053	0,065	0,078	0,080	0,053	0,084	0,072
Claroline	0,067	0,413	0,391	0,147	0,488	0,170	0,201	0,357	0,218	0,233	0,246
FLE	0,391	0,380	0,391	0,500	0,241	0,595	0,520	0,157	0,488	0,138	**0,438**
OLAT	0,151	0,147	0,151	0,288	0,218	0,170	0,201	0,406	0,241	0,545	0,244

mmeybodi@aut.ac.ir

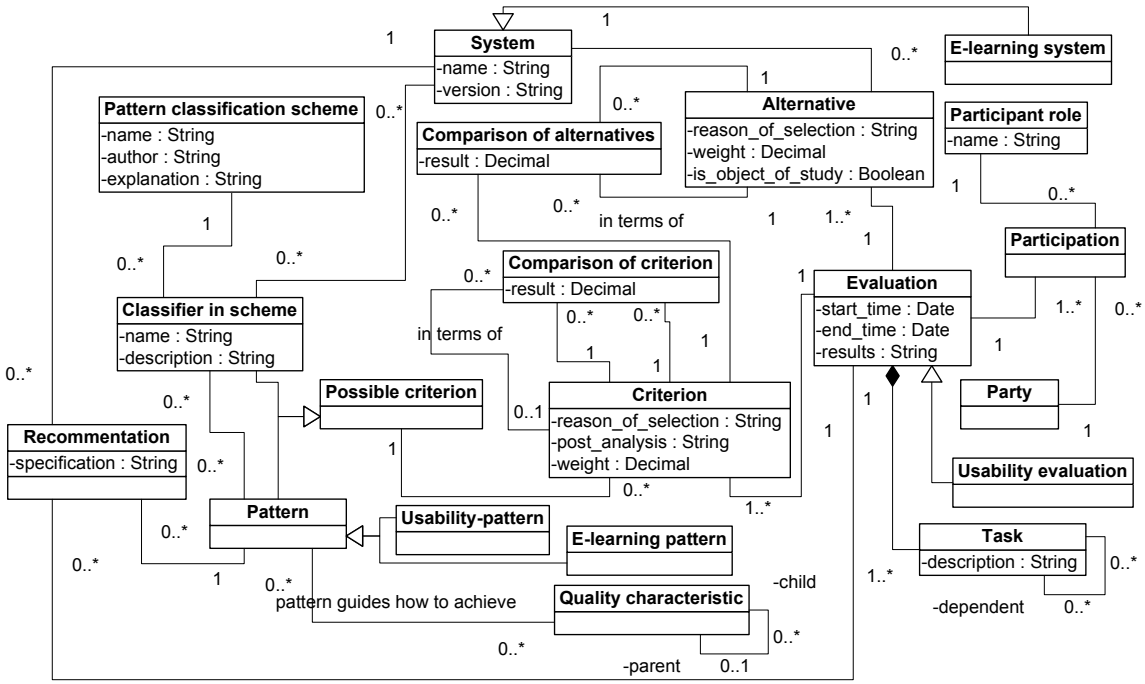


Fig. 1. A domain model of the proposed method.

A way of getting the opinions of potential users is to create the list of possible patterns what will be used for analysis and discuss it with them in order to find out what patterns they consider to be the most important.

Step 2: Analysis of the criteria is a usual step in AHP. In our approach the criteria for the evaluation are patterns. On the other hand, since we have two different types of patterns (web usability and e-learning) we have to do criteria comparisons in two steps. Firstly, we have to determine the relative importance of different types of patterns in the context of the study by using AHP. After that we compare the patterns that have the same type with each other. The patterns can be from different fields (like usability and e-learning in our case). Therefore, different experts should discuss the importance of different types of patterns.

Step 3: In order to evaluate all the important features of a system it would be useful to write down the evaluation tasks. If all the tasks are specified, then the evaluation could take less time compared with the case when the evaluator has to look through *all* the functions of the system. In addition, if we have the list of tasks, then we could easily repeat the evaluation. For example, reevaluation allows us to make sure that the changes to the system have improved the situation. In addition, we can use the specification of evaluations in case of evaluating similar systems in the future. After everything is ready we can carry out the evaluation according to the plan.

We would like to point out that the activities that we used for the evaluation have much in common with the methods mentioned in section V. We evaluate the systems to see if they are following the specific rules (patterns) like in heuristic evaluation. The recommendation to write down the tasks corresponds to cognitive walkthrough. In our evaluation, we tried to evaluate the main features of the systems like in feature inspection. And the inclusion of "Follow standards" pattern into the set of criteria shows that we have done some standards inspection as well.

Step 4: The next step would be to analyze the results of evaluations and to decide, how well each pattern is implemented in each of the systems.

Step 5: If we compare several systems with each other, then we could calculate the final weights for the systems according to AHP.

Step 6: Find the patterns, the implementation of which is the worst. If we have a working system, then we could think how to improve the situation and solve the problems.

Step 7: Run the evaluation from step 3 again in order to estimate whether the situation has improved or not.

Step 8: This step could be either the last step of the analysis, or the first step of a new iteration. During this step we should decide what patterns were useful and what were not. If some patterns proved to be not that useful as we thought, then we have to replace them with some other patterns in the first step of a new iteration.

mmeybodi@aut.ac.ir

There are two possibilities for making iterations in this method. One is to make evaluation and the following analysis until the results are good enough (Steps 3 to 7). Another possibility is to repeat the entire process after one iteration (steps 1-8) is completed.

Fig. 1 presents a domain model of the proposed approach. Each evaluation uses one or more alternatives and one or more criterion. The alternatives are systems. One or more alternatives are the objects of study, the quality of which we want to evaluate. An e-learning system is a kind of system. The criteria are either patterns or elements of pattern classification scheme. Usability patterns and e-learning patterns are kinds of patterns. Each evaluation consists of one or more tasks. There could be dependencies between tasks. A usability evaluation is a kind of evaluation. Each evaluation has one or more associated parties who participate in the evaluation in some role. Based on the results of executing the tasks it is possible to perform pairwise comparison of criteria (possibly in terms of other criterion) and pairwise comparison of alternatives in terms of each criterion.

The use of a pattern could help us to improve one or more quality characteristic of a system. An evaluation can produce recommendation about the use of a pattern in a system. Quality characteristics can form a hierarchy [5]. Each pattern is characterized by zero or more classifiers. Each classifier belongs to exactly one classification scheme. It is possible that a pattern can be associated with more than one classifier, which belong to the same classification scheme. Examples of classification schemes of patterns are Domain, Purpose and Scale. For instance, a domain of a pattern could be telecommunication, medicine or e-learning. In addition, each system is associated with zero or more classifiers. If a system is associated with a classifier, then it means that the system can take advantage of patterns that have this particular associated classifier. Based on this information we can find criteria (patterns) that we can use in order to evaluate a system.

VIII. Future Development of the Method

Actually, this method can work as a general pattern-based analysis method of systems. The goal is to create an information system that allows us to describe the systems that we want to analyze (in terms of usability, functionality or any other aspect) and manage the results of analysis. For example, if we take some other system and will analyze it based on some other aspect, then we should change:

- systems that we analyze;
- patterns that are the criteria;
- the tasks that must be completed during the analysis.

We can change the systems, use other kinds of patterns and put together new tasks (see Fig. 1). But the method itself does not change. In this general system, it should be possible to describe different types of systems, patterns and tasks. The creation of that system is the goal of our future studies.

IX. Conclusions

In this paper, we proposed a novel usability-evaluation method that uses patterns and Analytic Hierarchy Process. We applied this method in order to evaluate 4 e-learning environments. We used 5 usability patterns and 5 e-learning patterns in the analysis. The result of evaluation is that the Future Learning Environment is the best e-learning system among the systems that were under consideration. Based on this study we created a generalized specification of the method. We described steps of this method and also presented a domain model.

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mmeybodi@aut.ac.ir

Computerized Education: What is Behind the Attractive Curtain?

G.G. Kuleshov
Touro College
27 West 23rd Street, New York, 10010, USA
gkuleshov@tourou.edu

Abstract

This study is aimed to analyze the internal structure and effectiveness of computerized (web-enhanced on-campus and on-line) education that is currently spread worldwide and which appears to be irreversible. Most publications dealing with computerized education are focused on its advantages and only a few of them contain cautious and reasonable skepticism based on the fact that the computerized technology usage (and the Internet as its delivery system) does not guarantee a better educational process. In contrast with a traditional style, which is based on Instructor-Student communication, the computerized approach involves at least one more party, the technical support staff, operating within either Intranet or Internet environment. This component could be involved into the educational process either in succession or in parallel providing opposite outcomes to the educational effectiveness. The formal algorithm describing the computerized educational process is developed on the basis of a combination of the AND and OR logical operators applied to the set of communication topologies. This algorithm allows comparing qualitatively and quantitatively different scenarios of learning as well as estimating the relative contribution of each local component into the entire process.

Categories and Subject Descriptors
K.3.2 **[Computers and Education]** Computers and Science Education

General Terms
Communication Topology, Effectiveness, Educational Technology

Keywords
Distance Education, Learning Styles, Parallel and Series Collaborations, Simplified Transference Functions, Teaching Effectiveness Measurement

Introduction

For about ten years, the most popular tendency in education has been the development of Internet based on-line, either Internet or Intranet enhanced, or just computerized on-campus courses. "During the development process, for example, the design and development of on-line courses may be done by an instructional designer collaborating with a senior faculty member. During course delivery, another faculty member may take over the functions of directing, supporting, and assessing the learning of students" [1]. Such an approach is already utilized in many universities – faculties are divided into two groups: (a) course developers (senior faculties), and (b) "another faculty members" (core faculties) whose duties include all the above mentioned functions. At least three teams are supposed to work consistently in this contemporary style of education; they are (i) faculties, (ii) technical support staff, and (iii) students. The other possible teams are mentors, lab assistants, both real or virtual lab equipment and their instructions if any, computerized tests, and so on [2, 3]. Switching from the regular on-campus style to a remote one is not as easy as turning on the light in the classroom. If an aspiration to this contemporary style of teaching is not supported by adequately prepared faculties, technical support staff and students, it will lead to the degradation of the teaching process rather than to its improvement. It is already a subject of wide discussion in the media [4 – 7] and professional educational organizations [8]. "I see a continual slip in higher education standards. I'm leaning toward sending my child to a foreign university because I'm anticipating a snowball effect of these ridiculously low standards that will invade U.S. universities in two to three years and graduate schools in 10 years", wrote Nancy Chiu a public high school teacher in Flushing, New York [7]. "The numbers are amazing. In the United States, E-Learning enrollments grew by 35% in 2005; close to 20% of postsecondary enrollments are on-line, half of them in junior colleges. And there are no indications of a slowdown any time soon. There are, however, disturbing indications that quality is being affected negatively. Nearly half the US professorate is part-time, and significant numbers of full-timers avoid teaching on-line courses if they can. Recent study indicating a clear link between drop-out rates in community colleges and the number of full-time professors employed must raise questions about the impact of on-line courses taught primarily by adjunct and part-time faculty receiving pay [that] the AAUP (American Association of University Professors) once described as near the poverty line. Since most E-Learning takes place at institutions in the lowest tier of the *US News* [*& World Report*] rankings, adequate finding of quality programs is always in doubt" [8].

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 123–128.
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mmeybodi@aut.ac.ir

During the last seven years, I have had many occasions to observe such a situation at one institution where I used to teach an online course. I will illustrate my point by examples taken from recent web enhanced courses which I have evaluated as a mentor. It is important that we learn what we can from the existing initiatives, adapting and adopting the good aspects, and avoiding repeating the more negative ones. The starting point of the study is analysis of two styles of collaboration in a closed chain instructor – interface – student – interface – instructor.

Collaboration in Parallel and in Series

There are two different kind of collaboration which should be distinguished for our analysis. They are parallel collaboration and series collaboration. The first one is a team working together with each member's contribution to be added to the solution at specific weight which in turn is proportional to the particular member capability. An example is a group of students trying to solve a problem when it does not matter who will solve it, as long as the problem is solved. The effectiveness of such a team (or the probability of success) could be easily estimated via local capabilities (or probabilities) of participants. This situation is very similar to the conductivity of resistors connected in parallel: the total conductivity is greater than conductivity of any particular branch of a circuit. The other style of collaboration is the situation when each next member of a team follows his or her predecessor, so the final result again depends on each step contribution, but it has been done in a different way: it is similar to the series connection of resistors when the total resistance is equal to the sum of particular resistances. In such a case, the total resistance is greater than any one particular resistance, and the conductivity falls down up to zero if at least one component has conductivity of zero value[1].

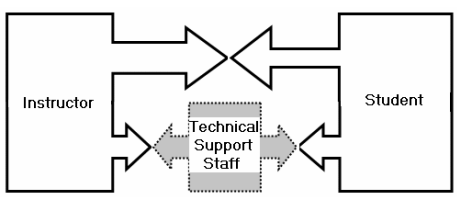


Figure 1. Sequential and parallel relationships between Instructor and Student for Web enhanced course.

Figure 1 represents collaborations which appeared in web enhanced teaching whereas the traditional (on-campus) style utilizes the upper branch only and the on-line style utilizes the bottom branch only. In the probability theory, this case is known as "general multiplication law" or AND logical relationship between two or more events whereas the parallel connection represents OR logical relationship. The easy graph below (Figure 2) illustrates these two opposite tendencies: increase the effectiveness of parallel collaboration and decrease the effectiveness of series collaboration as a function of number of components of the same local effectiveness.

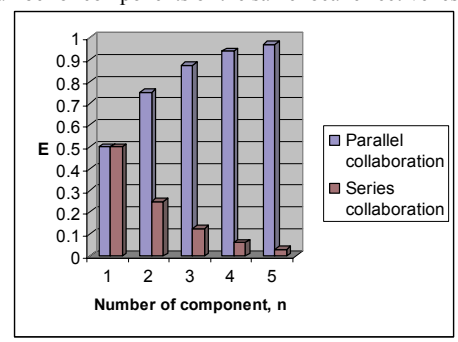


Figure 2. Relative effectiveness of collaboration as a function of number of component at 50% permanent local effectiveness.

Practically, the relationships between components and their mutual interactions are much more complicated, but as the first approximation, the simplest combinations of above logical elements deserve to be considered qualitatively and, if possible, quantitatively.

Transference Functions and Formal Analysis

In order to formalize the analysis of the educational process, the application of a simplified analog of transference functions appears to be appropriate approach for evaluations, quantitative estimates, and comparisons. Let us define the simplified transference function of educational process, E, as a product of local effectiveness, $E_i^{(s)}$ for each i-th series component (logical AND or "general multiplication law")

$$E = \prod_{i=1}^{n} E_i^{(s)} , \qquad (1)$$

and as

$$E = 1 - \prod_{i=1}^{n} (1 - E_i^{(p)}) , \qquad (2)$$

for each i-th parallel component, $E_i^{(p)}$, (logical OR or complement effectiveness to the local complement effectiveness product) of a chain with all the $0 \le E_i \le 1$; where n is the number of component. Four elementary components are effectiveness of an instructor, E_I; a mentor, E_M; a technical

[1] I apologize for usage of this specific isomorphism which could be not helpful for some readers and looks trivial for science teachers.

mmeybodi@aut.ac.ir

support, E_T; a student, E_S; and their five topologies and simplified transference functions (STF) are shown at Figure 3.

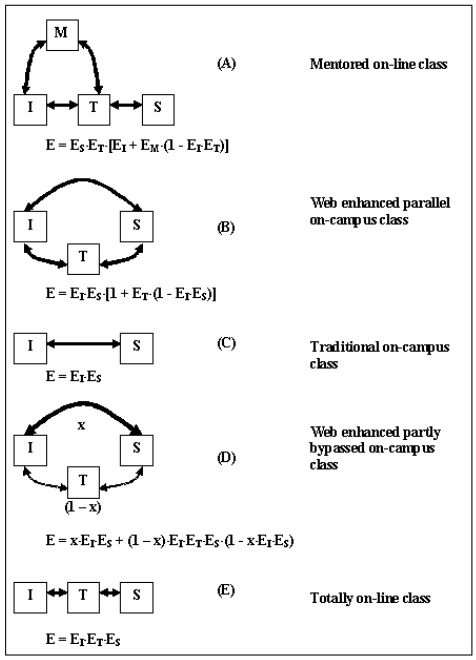


Figure 3. Communication topologies and their STF (I – Instructor; M –Mentor, S – Student; T – Tech Support).

The first conclusion that can be made by analysis of the above description is the highest effectiveness of mentored on-line class (A) at non-zero E_T factor. The second place in the effectiveness hierarchy is occupied by web enhanced paralleled on-campus class (B). The third place is occupied by traditional on-campus class (C). The fourth place is occupied by partly bypassed web enhanced process (D) which means that part of process (x) utilizes the traditional style and the complement part (1 – x) utilizes the on-line style; obviously, at $X \to 1$, (D) $\to$ (C) whereas at $X \to 0$, (D) $\to$ (E). The internal degree of freedom, x, at the same time may reduce effectiveness of case (D) in nonlinear fashion providing E_{min} value less than E of case (E) at

$$x_{\min} = \frac{E_I E_T E_S + E_T - 1}{2E_I E_T E_S}, \qquad (3)$$

(see Figure 4) which is greater or equal to 0 at $E_T \geq (1 + E_I E_S)^{-1}$. The very last position in the above descending hierarchical sequence of effectiveness is occupied by a totally on-line style of learning (E). As stated in my recent publication [2], this fact is not surprising because of the specific purpose of on-line education to be rather long distance and asynchronous than to be *a priori* much more effective. Ironically, I have participated in both the most effective mentored web enhanced version (A) at Touro University International and the most ineffective versions (D and E) which are still utilized at Touro College.

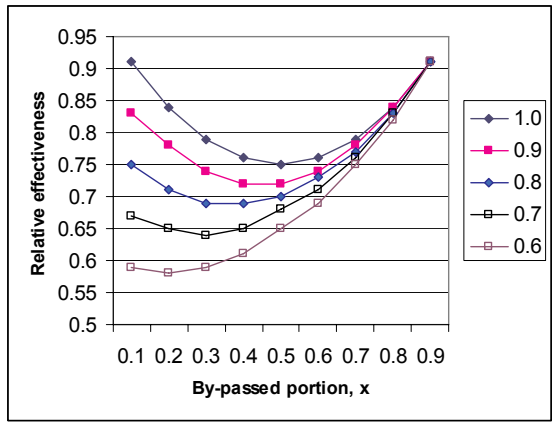


Figure 4. Total relative effectiveness, E, as a function of by-passed portion of the course, x, and E_T (legends) at $E_I = 1$, and $E_S = 1$.

The second conclusion, as it follows from Figure 4, is that at certain distribution of the learning process between two options (web enhanced and traditional), the usage of technology, E_T, which appears to be critical component, might reduce effectiveness even below the on-line only style of learning (x = 0). Unfortunately, such an approach (partly bypassed web enhanced style) is very popular among adjunct faculties.

Generally, the most important conclusion is that the proposed algorithm allows for the setting up of quantitative measure for different learning style effectiveness as a function of the process topology which could be implemented by a number of other elements: one on one tutoring, external interactive on-line tutorial, virtual lab assignments, computerized tests and so on. Now, it is the time to discuss local effectiveness of an instructor, E_I, technical support staff, E_T, and student, E_S, as well as the distribution of web enhanced course material among regular, x, and online (1–x) parallel branches all of which are still unknown variables.

Example of STF Application and Estimates

The proposed elementary quantitative approach could be applied to estimate and then compare the different style of teaching either within the same institution or in different institutions. Let us do that taking into account the above

mmeybodi@aut.ac.ir

estimates for four basic components of educational process connected in different ways.

Instead of the development of a standard course (including course outline, course notes, course homework and quizzes assignments, course threaded discussions, course external links, and exams) as a cartridge associated with name of the developer to be run by adjunct instructors, most web enhanced and online courses which are produced by adjunct instructors have almost nothing common with courses developed by full time faculty[2]. Average readiness to use technology for the five full time computer science department faculties I have observed within the last ten semesters is about 80% whereas the same characteristic for twenty-five adjunct faculties is about or below 70%. So, the average value of $E_I = .72 \pm .07$ at 90% level of confidence.

The national standards of technology in education are well developed documents available at the International Society for Technology in Education (ISTE) web site [9]. There is a clear and growing need to measure and improve performance of these standards: "Employers report repeatedly that many new graduates they hire are not prepared to work, lacking the critical thinking, writing and problem-solving skills needed in today's workplaces", stated the Commission on the Future of Higher Education [10]. Much more optimistic, for example, is the anonymous statement in a local publication: "It was no longer necessary for a person to live in New York City to benefit from a quality Touro College education. All it required was a computer, Internet connection, and a drive to succeed" [11]. Having been employed at Touro College for about fifteen years, I do not think so and still believe that there are a lot of possibilities for technology in education improvement. As any kind of innovation activity, usage of technology in education should start with formulation of both the target and the resources which all together create what we call the concept of innovation. An absence of concept has sometimes been substituted for the magic of big numbers, not a quality, resulting in loss of what has been assumed to be a target. Professionalism for technical support staff means, first of all, clearly understanding the place and role of team members in the educational process. The second task is the rational organization of teaching/learning process in order to reach (not to declare) "the highest level of education" which means creative collaboration of instructional designer with a senior faculty member. "That experience convinced me that instructional technology training without a strong pedagogical foundation is a bit like learning to use very good kitchen equipment with no knowledge of food", wrote H. Wach of Bronx Community College [12]. It is hard to evaluate positively the readiness of Touro College technical support staff to use technology[3] because most of their activities are not based on any kind of logically consistent concept. They have software which is, generally speaking, neither worse nor better than any other, but it still is not used properly. Below are a few examples of inadequate usage of technology.

Example 1 (*inadequate usage of Internet resources*). Adjunct faculty with a master's degree in adult education is teaching algebra-based Digital Electronics courses as web enhanced ones. Having neither a general science background nor necessary minimum of physics and mathematics knowledge, he has implemented his course web site with links to Wikipedia as shown below.

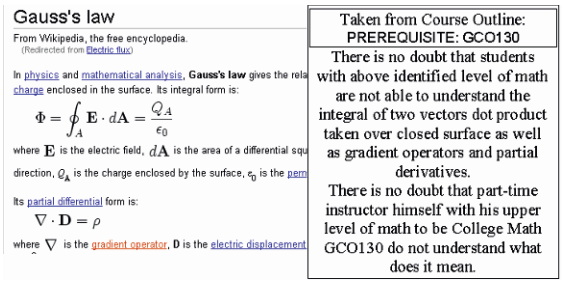


Figure 5. Contents of hyperlink "Coulomb" adjunct faculty have used to "explain" Gauss's law to students with College Math as an upper level of mathematical experience.

Example 2 (*inadequate usage of web sites themselves*). One of my duties as full-time faculty is observing and coaching adjunct instructors to ensure that "we present the highest level of instruction to our students that we can". The number of courses to be observed myself per semester varies from three to seven. For the last semester (Spring 2007), in the sixth week, I found one course web site empty for 90%, the second one for 99% (only the course outline had been posted), and the third one for 100% (it is hard to believe but the instructor had not been "enrolled" into his own course; on the seventh week of the semester, he, finally, got access to his web site as a result of my request.)[4].

Example 3 *(inadequate enrollment option usage)*. Teaching on-line courses, I discovered one day that the list of enrolled students grew up almost every day. Of course, I did send a memo asking for clarification what was going on with my

[2] I am not sure that one adjunct instructor who is currently teaching Digital Electronics course is able to pass the final exam I have designed for and used with my students.

[3] The situation with support staff and technology at Touro College looks like poster in a movie theater at the beginning of the 20th century: "Don't fire the pianist please: he plays as well as he can".

[4] By the way, this is in contradiction with the institution's policy which states that "an adjunct that does not use Blackboard in the spring [2006] will not be rehired in the fall".

mmeybodi@aut.ac.ir

course on the seventh week of the semester. This is the literal answer: "*you have obviously found the 'Achilles heel' in our system, namely, that any person, anywhere in the world, could enroll themselves in a Blackboard course, and automatically pop in into the course.*"

Example 4 *(inadequate usage of Blackboard environment).* The standard routine options (functions) of Blackboard environment such as "Course Copy" initially worked well but get destroyed by unprofessional technical support staff. This is the literal response of the Blackboard administrator received 49 hours after complaint: "*When courses are copied, the course menu and items may be ordered incorrectly or have duplicates with the same number. To resolve this matter, one must re-arrange them in correct order, and they will henceforth remain in the correct arrangement*". Can you imagine, lets say, a calculator that provides you with the result of multiplication of 6 and 2 to be 21, the same digits appear as they should be, the only sequence is a little changed; and then the suggestion of "specialist": if you are not satisfied with the result, you can either apply the addition arithmetic action instead of multiplication: just add 2 six times or re-arrange the digits yourself.

Example 5 (*inadequate self-identification of instructors*). Most instructors do not understand the difference between the Academic Rank and the activity identifying themselves on Touro College web sites as "professors" whereas some of them have not yet achieved the higher degrees. Can you imagine any battalion populated by generals only? You can find such a "battalion" at the Desktop Publishing division web site of Touro College. Can you imagine a bachelor in municipal transportation who is teaching advanced course "Networking in the Education Environment II" in the Master of Science in Instructional Technology program? You can find this "professor" at Summer II 2007 schedule posted on Touro web site.

The list of examples could be continued[5] but let us ask ourselves the question what is the scale of such a destructive impact to the educational process? According to the cited publication [10], "this past fall [2006] semester, there were more than 4500 students using Blackboard for more than 150 online courses and more than 450 Web-enhanced courses", then the degradation factors are about 4500 for individuals and about 600 for courses per semester. Does it leave any doubt that "Touro is taking a leadership role in online instruction" [10]?

According to the above, the average effectiveness of the technical support staff at Touro could not be estimated to be greater than 0.5 ± 0.1 keeping the real value within the range of $0.4 \le E_T \le 0.6$.

Preparation of students to take either a web enhanced or on-line course depends on whether or not computer science is the major for them. If it is, the readiness to work with interactive materials such as Blackboard environment, Internet tutorial and so on is about 9 of 10 or $E_S = 0.9 \pm 0.1$ whereas among non-computer science majoring students, only 7 of 10 demonstrate the satisfactory readiness ($E_S = 0.7 \pm 0.1$). So, under the assumption of approximate balance between these two groups, the estimate of students' average readiness to take computerized courses is about 0.8 ± 0.1. Are there any organizational steps that promote elevation of this important characteristic? Yes, they are (i) request to pass no credit exam confirming student's minimum knowledge of both the computer and the utilized environment; (ii) set up the animated "Demo" course providing students with basic options and tools of learning activity; (iii) keep up the logical sequence of courses offered to the students on each single semester. The same average estimated for 450 students at TUI University is 0.95 ± 0.05.
STF estimates of five Figure 3 topologies are listed in Table 1.

Table 1. Comparison of teaching relative effectiveness within one college (assumed $E_I = 0.72$; $E_T = 0.50$; $E_S = 0.80$; and x = 0.50) and with the other online university (assumed $E_M = 0.95$; $E_I = 0.90$; $E_T = 0.99$; $E_S = 0.90$).

Teaching style (Figure 3)	Relative effectiveness, %	
	Touro College	Online TUI University
(A)	-	89
(B)	70	-
(C)	58	-
(D)	49	-
(E)	29	-

The above table represents such a comparison making measurable the different teaching styles and their degradation in the listed sequence. Of course, evaluation of the entire set of component (E_M, E_I, E_T, E_S, x, and other ones) deserves the special and more detailed consideration. The point of this study was to develop a common quantitative approach which allows analysis of learning process effectiveness in logical, uniform, and non-controversial fashion. Generally, the assessment and ranking of higher education institutions still continues to be disputable. "The heads of a few liberal arts colleges have tried to organize a boycott of this [published in August 27, 2007 issue] rankings and received a lot of press coverage. They've accused us of all manner of sins, including oversimplifying complex institutions and, in one memorable quote, of exuding "real evil", wrote Brian Kelly, the Editor of *U.S. News & World Report* [13]. The story behind the

[5] It is hard to believe, but I knew one deputy of head of the department responsible for scheduling who was not able to calculate properly the time distance between 11:40 AM and 11:30 AM.

mmeybodi@aut.ac.ir

attractive digital curtain of computerized education is still waiting for analysis and investigation.

Conclusion

The controversial situation with visible advantages and hidden disadvantages of distance education recognized by many authors raises the problem of defining a measure of teaching effectiveness using different styles. As has been emphasized in [14, 15], there is no "standard instrument in the literature for evaluating learning effectiveness. It would appear that most institutions develop their own course evaluation instruments to suit their own purposes". The proposed algorithm could be considered as the very first step toward development of an objective and logically consistent measure of expected effectiveness of a particular educational process. Internal self-consistency of proposed general approach makes it possible to analyze and compare different scenarios of computerized education quantitatively as well as either adopt or reject certain option (component) of instructional technology. It could be implemented by standardization of all the internal variables definitions (estimates), by comparison with other quantitative approaches based on the analysis of knowledge (what is the final target of education) as a function of different components and styles of communication.

Acknowledgement

I would like to thank Professor Andrei Toom of Federal University at Pernambuco, Brazil, and my colleague Joyce Elizabeth Carbine for helpful discussion and all my students at TUI University and Touro College whose enthusiasm and support encouraged me to develop and to teach both the online and Web enhanced courses. The views expressed are those of the author and do not reflect the official policy or position of TUI University and Touro College.

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mmeybodi@aut.ac.ir

E-Education Over Homogenous Network

Eren Küren
Computer Engineering
European University of Lefke
Gemikonagi, T.R.N.C.
ekuren@lefke.edu.tr

Akin Cellatoglu
Computer Engineering
European University of Lefke
Gemikonagi, T.R.N.C.
a.cellatoglu@lefke.edu.tr

Abstract - **The aim of this project is teach all humans at any time anywhere by using HCI (Human Computer Interaction) principles and educational physiologies' concepts. All standards and principles of the HCI and Educational physiologies are used in the project. Learning goals of the paper is to give experiences to users about their courses and teaches. Project allows that secure system using and ergonomic field study in advanced and beginner types of interface. It can be applied to all courses e.g. C programming language, English Language for Child e.t.c. the idea comes from international field studies transforming face-to-face higher-education courses to Computer based teaching delivery. Central to the research value is the 'how' adult learning, instruction, organizational science and systems theories are integrated for the benefit of organization, student, professor to support efficient and effective e-teaching technology, informed by adult learning goal theory. Contemporary theoretical views of course design and delivery can be articulated within frameworks originating in educational psychology and other social science fields. E-Learning is term covering a wide set of applications and processes, such as Web-Base learning, Computer-Base Learning, virtual Classrooms and digital collaboration. This study aim is about " how to teach the adult learners using Technological Environment and E-Learning object principles". The project includes a system to manage and teach the student with Computer-Based Application (CBA). This paper includes how to create the e-learning system. The paper consists of learning principles (e.g. Motivation, Cognition, and Efficacy) for both designing and teaching. The application of systems methodologies to structure content and delivery (e.g. programmed instruction, test-banks, and examinations), applying instructional techniques (met cognitive learning-to-learn approaches), and by leveraging computer systems (relational database design, teaching with object oriented technology) for effective and efficient desktop application adult course design and delivery**

Keywords: E-Learning, CBA, HCI .

I. INTRODUCTION

E-Learning is a term covering a wide set of applications and processes, such as Web-Base learning, Computer-Base Learning, virtual Classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio and videotape, satellite broadcast, Interactive TV, CD-ROM, and more. More and more Universities and Colleges are interested in providing training for their faculty that will enable them to create technology-base educational products and use them to aid the teaching/learning process. Using technology to enhance the educational process involves more than just learning how to use specific pieces of hardware and software. This paper includes about "the how to teach the adult learners using Technological Environment and E-Learning object principles" and a system to manage and teach the student with Computer-Based Application (CBA). The paper consists of learning principles (e.g. Motivation, Cognition, and Efficacy) for both designing and teaching. The application of systems methodologies to structure content and delivery (e.g. programmed instruction, test-banks, and exams), Applying instructional techniques (met cognitive learning-to-learn approaches), and by leveraging computer systems (relational database design, teaching with object oriented technology) for effective and efficient desktop application adult course design and delivery.

A. What is e-learning?

E-Learning is a term covering a wide set of applications and processes, such as Web-Base learning, Computer-Base Learning, virtual Classrooms, and digital collaboration. It includes the delivery of content via Internet, intranet/extranet (LAN/WAN), audio and videotape, satellite broadcast, Interactive TV, CD-ROM, and more. More and more Universities and Colleges are interested in providing training for their faculty that will enable them to create technology-base educational products and use them to aid the teaching/learning process. Using technology to enhance the educational process involves more than just learning how to use specific pieces of hardware and software.

B. History of E-learning

The initial training methods of interrupting work to attend classroom training or learning from the first wave of online solutions, have both become obsolete. The first wave was between 1994 and 1999. The Internet is powering a second wave of training methods that can custom fit to your work schedules, budget, and training preferences through innovative training technologies, flexible delivery methods, engaging multimedia, and live audio. The second wave was started in 2000 and is continuing. The second wave includes technological advances such as JAVA/IP networking applications, rich streaming media, high-bandwidth access, and advanced web-site design. Today, live instructor led training

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 129–134.
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(ILT) via the web can be combined with real-time mentoring. In the illustration below, see that hype-cycle of e-learning.

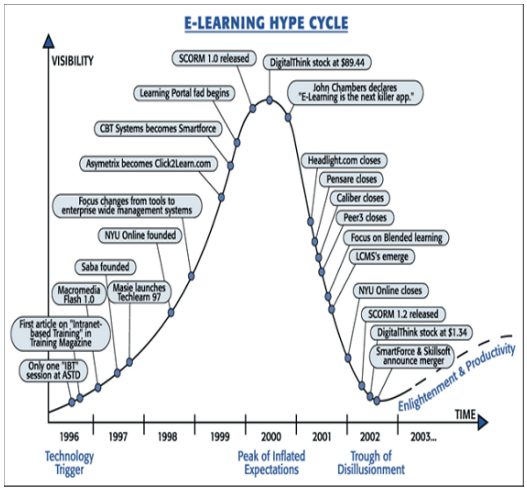


Fig. 1.E-learning Heap Cycle (e-learningguru) [8]

C. Development model of the pedagogy-based training

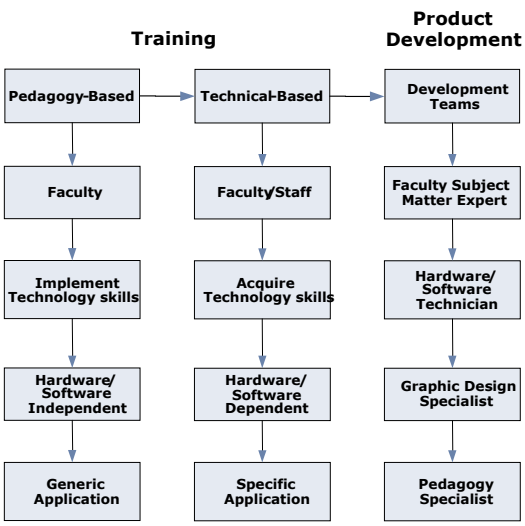


Fig. 2 Training and Product Development model

Above scheme shows you that, the states of the pedagogy-based training technology. Traditional training/development approaches have placed the burden of educational product development on the shoulders of the faculty. Most colleges offer technology workshops designed to help the faculty acquire various technology skills. The purpose of the traditional classes is to teach the faculty to develop their own technology products (e.g. web sites, multimedia presentation, etc.).

D. Facilitating Communication(Instructivist view)

An instructivist view of teacher/learning promotes three predominate types of communication (figure 3). According to instructivist principles, learning flows in a mostly unidirectional path, proceeding from the knowledgeable authority (teacher), or from instructional content, to the passive learner. Example, an instructor may employ a "Socratic" or question/answer style in the classroom, however if the teacher is "leading" students towards pre-planned learning objectives, then this application of the Socratic method is still instructivist-Based.

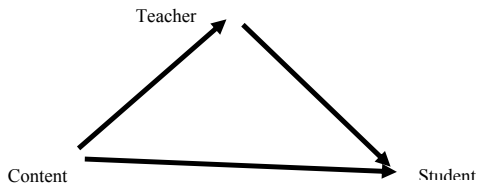


Fig .3: Facilitating Communication: Basic View

E. Content Design Methodology

Beyond the obvious linking of pedagogy and course content to learning objectives, a critical aspect of Computer – Based course design is the selection and organization of subject matter, further complicated by the presence of multiple and often overlapping, courses and programs, typical of many universities.

II. ADULT LEARNING PRINCIPLES

A. How memory works?

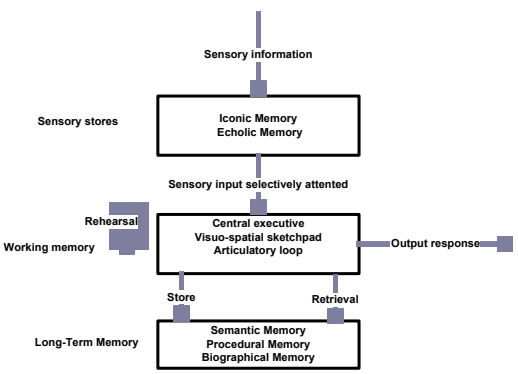


Fig. 4 Multi-Store Memory Model

Above figure shows how the working memory works and saves it into long term memory.

B. Cognitive Styles

The notion of cognitive styles is fairly new. It grew out of research on how people perceive and organize information from the world around them. Differences in cognitive style have to do with "characteristic modes of perceiving,

mmeybodi@aut.ac.ir

remembering, thinking, problem solving, and decision making, reflective of information-processing regularities that develop... around underlying personality trends" (Messick, 1994) and not with intelligence. For example, certain individuals respond very quickly in most situations. Others are more reflective and slower to respond, even though both types of people may be equally knowledgeable about the task at hand.

C. *What is Motivation?*

Definition of motivation: Motivation is an internal state that arouses, directs, and maintains behavior. The study of motivation focuses on how and why people initiate actions directed toward specific goals, how intensively they are involved in the activity, how persistent they are in their attempts to reach these goals, and what they are thinking and feeling along the way.

1) Motivation: An internal state that arouses, directs, and maintains behaviour.

2) Intrinsic Motivation: motivation associated with activities that are their own reward.

3) Extrinsic Motivation: Motivation created by external tailors such as rewards and punishments.

TABLE I
FOUR VIEWS OF MOTIVATION

	Behavioral	**Humanistic**	**Cognitive**	**Sociocultural**
Source of Motivation	Extrinsic	Intrinsic	Intrinsic	Intrinsic
Important Influences	Rein forcers, rewards, incentives, and punishers	Need for self-esteem, self-fulfillment, and self-determination	Beliefs, attributions for success and failure, expectations	Engaged participation in learning communities maintaining identity through participation in activities of group
Key Theorists	Skinner	Maslow Deci	Weiner Graham	Lave Wenger

D. *The Information Processing Model of Memory*

There are a number of theories of Memory, but the most, common are the information, processing explanations (Ashcraft, 2002; Hun, & Ellis, 1999; Sternberg 1999). We will use this well-researched framework for examining learning and memory.

E. *An Overview of the Model*

Early information processing views of memory used the computer as a model. Like the computer, the human mind takes in information, performs operations on it to change its form and content, stores the information, retrieves it when needed, and generates responses to it. Thus, processing involves gathering information and organizing it in relation to what you already know, or encoding; holding information, or storage; and getting at the information when needed, or retrieval. The whole system is guided by control processes that determine how and when information will flow through the system. For most cognitive psychologists, the computer model is only a metaphor for human mental activity. But other cognitive scientists, particularly those studying artificial intelligence, try to design and program computers to "think" and solve problems like human beings (Anderson, 1995a; Schunk, 2000). Some theorists suggest that the operation, of the brain resembles a large number of very slow computers, all operating in parallel (at the same time), with each computer dedicated to a different, specific task (Ashcraft, 2002). Figure 5 is a schematic representation of a typical .information model of memory, derived from the ideas of several theorists. Information is encoded in sensory memory where perception and attention determine what will be held in working memory for further use. In working memory, new information connects with knowledge from long-term memory. Thoroughly processed and connected information becomes part of long-term memory, and can be activated to return to working memory. Implicit memories are formed with out conscious effort.

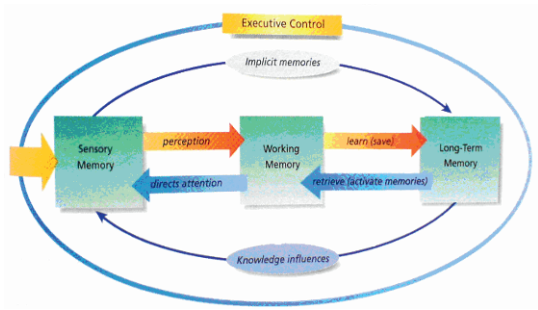


Fig. 5: The Information Processing Model of Memory

F. *Sensor Memory*

Sensor memory is the initial processing that transforms these incoming stimuli into information so we can make sense of them. Even though sights and sound may last only fractions of a second, the transformations (information) that represent these sensations are briefly held in the sensory register or sensory information store so that this initial processing can take place (Bruning, schraw, & Ronning, 1999).

G. *Working memory*

The information in sensor memory is available for further processing, as soon as it is noticed and transformed into patterns of images or sounds (or perhaps other types of sensory codes). Working memory is "the temporary storage of information that is being processed in any range of cognitive tasks" (Baddeley, 1986), working memory is the "workbench" of the memory system, the interface where new information is held temporarily and combined with knowledge from log-term memory. Working memory contains what you are thinking about at the moment. Working memory holds the information that you are focusing on at a given moment.

mmeybodi@aut.ac.ir

H. Four Stages of Cognitive Development

TABLE II
FOUR STAGES OF COGNITIVE DEVELOPMENT

Stage	Approximate Age	Characteristics
Sensorimotor	0-2 years	Begins to make use of imitation, memory, and thought. Begins to recognize that objects do not cease to exit when they are hidden. Moves from reflex actions to goal-directed activity.
Preoperational	2-7 years	Gradually develops use of language and ability to thing in symbolic form. Able to think operations though logically in one direction. Has difficulties seeing another person's point of view.
Concrete operational	7-11 years	Able to solve concrete (hands-on) problems in logical fashion. Understands laws of conservation and is able to classify and seriate. Understands reversibility.
Formal operational	11-adult	Able to solve abstract problems in logical fashion. Becomes more scientific in thinking. Develops concerns about social issues, identity.
Source: From Piaget's Theory of cognitive and Affective Development (5th ed.), by B.J. Wadsworth. © 1996		

1) Short-Term memory: Component of memory system that holds information for about 20 seconds.

2) Central executive: the part of working memory that is responsible for monitoring and directing attention and other mental resources.

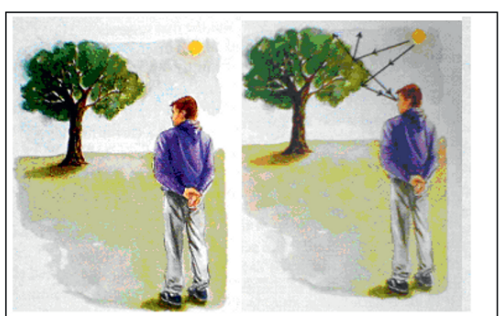
3) Phonological loop: Part of working memory. A memory rehearsal system for verbal and sound information of about 1.5 to 2 seconds, there are a number of differences between working and long-term memory, as you can see in Table 3. Information enters working memory very quickly. To move information into long-term storage requires more time and a bit of effort. Whereas the capacity of working memory is limited, the capacity of long-term memory appears to be, for all practical purposes, unlimited.

TABLE III
WORKING AND LONG-TERM MEMORY

Type of Memory	Input	Capacity	Duration	Contents	Retrieval
Working	Very Fast	Limited	Very brief: 5-20 sec.	Words, images, ideas, sentences	Immediate
Long-Term	Relatively slow	Practically unlimited	Practically unlimited	Propositional networks, schemata, productions, episodes, perhaps images	Depends on representation and organization
Source: From comprehension and learning: a conceptual framework for teachers, by E.Smith, 1975 [1]					

I. Understanding complex Concepts

A good definition has two elements: a reference to any more general category for the new concept, and a statement of the new concept's defining attributes (Klausmeirer, 1976). For example, a fruit is food (general category) with seeds in the parts (defining attributes). An equilateral triangle is a plane, a simple, closed figure (general category), with three equal sides and three equal angles (defining attributes). This kind of definition helps place the concept in a schema of related knowledge. In teaching some concepts' "a picture is worth a thousand words" or at least a few hundred. Seeing and handling specific examples or pictures of examples helps young children learn concepts. For students of all ages, the complex concepts in history, science, and mathematics can often be illustrated in diagrams or graphs. For example, Anderson and Smith (1983) found that when their students just read about the concept of light, only 20% could understand the role of reflected light in our ability to see objects. But when the students worked with diagrams such as the one in Figure 6, almost 80% understood the concept.



Q) When sunlight strikes the tree it helps the boy to see the tree. How does it do this?

A) Some of the light bounces (is reflected) off the tree and goes to the boy's eyes.

Fig. 6: Understanding Complex Concepts

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III. CREATING DYNAMIC LEARNING OBJECTS

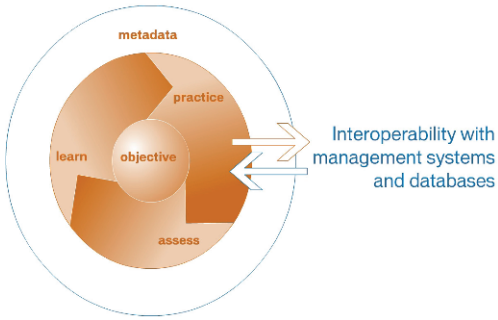


Fig 7. Structure of a Learning Object

A. The Evaluation Process of a Student

Every student taking course through DLMSS (Dynamic Learning Management System Software) encounters with three types of testing schemes, Pre-Test, Post-Test and Exam. The flowchart in the figure 7 explains the process of such a student being evaluated while taking a course.

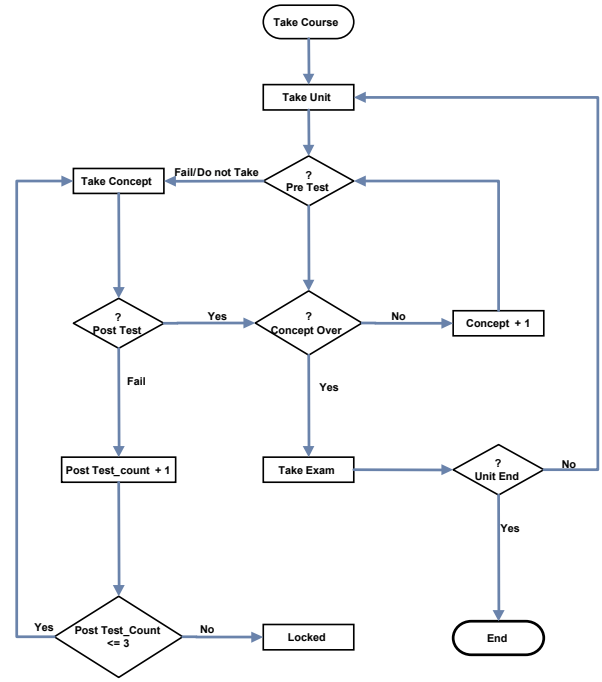


Fig. 8: Flowchart of the Evaluation process of a student

B. Application Software Architecture

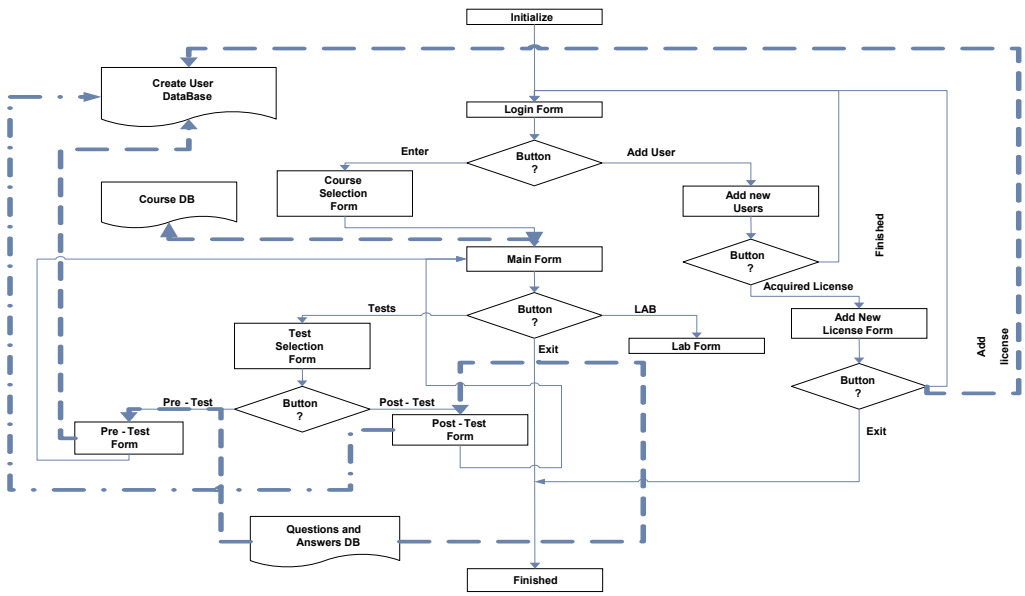


Fig. 9 Demo Application Design, Flow Chart

mmeybodi@aut.ac.ir

IV. CONCLUSIONS

The aim of this project is to teach all humans at any time anywhere by using HCI (Human Computer Interaction) principles. Learning goals of the paper is to give experience to user about given courses. Project allows to you that secure system using and ergonomic field study in advanced and beginner types of interface. It can be applied to all courses e.g. C programming language, English Language for Child e.t.c.

Future things are using web sites and use of the cyber class in it. The standards are used for teaching learners on the web. Therefore all lecturers can give their courses by using this system. Also in the project, transfer of educational physiology theory to technology based training. It is called CBA (Computer Based Application) this technology is used in demonstration software. The software has tune ability to teach course concepts to students and make laboratory sessions and exams. After all concepts are finished, program sends an analysis of students to lecturers. There is one technology for lab classes, which is picture description technique adding into the software in the future time for lab or presents some thing. Frogan (http://www.frogans.com) is an example for this technology. This technology is picture divided by the software and when mouse pointer coordinates on defined part, this part gets focused and when clicked event is occurred software controls this partition and controls the answers if it is correct or not.

A. Objectives

Increase the performance of the students. Always get practice and theoretical knowledge. Take Pre-Test and other examinations any time. Enter the lab session any time. And make practice on current concept. Courses can be repeated any time. When all concepts are finished student take exam. In slides, pictures and graphics help student to understand complex theories easily. Use presentation slides for teaching the courses easily. Windows Media Component application (Windows media Encoder) is used for creating Video Slides.

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mmeybodi@aut.ac.ir

From Software Engineering to Enterprise Engineering – Introduction to a Language-Critical Approach

Erich Ortner
Technische Universität Darmstadt
Development of Application Systems
64289 Darmstadt, Germany
Ortner@winf.tu-darmstadt.de

***Abstract*– With service-oriented architectures and the organization-centric development of application systems, we are experiencing the beginning of a reorientation in how information technology is used in the global economy as well as in our private lives. This trend has already impacted on the "System and Application Development" branch of study at colleges and universities. Language-critical Organization Theory has thus become a discipline in research and teaching. In the years to come, this shift of emphasis will broaden present endeavors and originate new interdisciplinary ones in research and development. Because of the global nature of these endeavors, it is important to look for a common basis for possible cooperation partners in this field. The necessary efforts are enormous and can only be managed successfully by working together. Looking at how the philosophy of science has developed throughout the twentieth century seems to imply that a) the primarily American analytic philosophy of science paired with b) the methodical constructivism of predominantly German origin (Erlangen and Constance) could form this common basis. In this paper, both philosophies will form the foundation substantiating practical development in the field of service-oriented architecture. The common foundation will also disclose what people must be able to do or, respectively, what they must know (understand) if they want to work successfully in the IT-industry in the future.**

I. INTRODUCTION

According to Aristotle (384-322 BC), *Architectonics* refers to the art and science of building, while the term *architecture* denotes the structure. In civil engineering, the proportion of "art" within the structuring activity is usually drawn upon to distinguish an architect (emphasis on art) from an engineer (emphasis on methodology).

For vendors and users of information technology, the term *service-oriented architecture* (SOA) has been an issue for about four years. Organization-centric Requirements Engineering (on a constructivistic basis) with reference to Applied Computer Science was proposed for the first time in 1980 [1]. The following observations are important to this concept today:

- *Organizational processes*, which, to some extent, offer a free choice (e.g. specific knowledge gained from experience) to the acting persons in particular steps of an occurrence are principally to be distinguished from the inherently different algorithmic computer processes (software and hardware). Therefore, organizational processes ought to be specified further by *language-critical organization theory* [2].
- Ubiquitous (= found everywhere) computer technology leads to the fact that presently almost any object (thing or occurrence) can be a medium in this technology.
- *Common languages,* (e.g. "ontologies", conceptual schema, ortho-languages) whether spoken by people or used in technology, always serve as a means for integration. This includes, to some extent, the integration of heterogeneous elements in a system or architecture.
- Today, the *meta-language* in application systems – the showpiece of system informatics – is firmly established within the overall architecture by means of repositories. For example, repositories are used to enable and facilitate the management of component-based solutions.
- In the field of constructive languages and consequently in research methods of various application fields, there has been considerable progress in the past few years ascribed to the *Unified Modeling Language (UML)*, whose development is still ongoing.
- There are predominantly three factors, which have instigated the necessity to start *organizing work globally*. These are: The fact that Enterprise Organization Theory is a part of Applied Computer Science, the comprehensive concept of application systems as *service-oriented architectures*, and the development of new technologies on the internet (Web 2.0), for example interactive applications [3]. It is essential to approach this organizational task from the position of dynamically organized enterprise networks that interact globally.

In the following, we will describe how the ProCEM® method (Process-Centric Enterprise Modeling & Management) meets the above-mentioned requirements, taking into

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 135–143.
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consideration the human needs. The basis for our description is the experience gained from accompanying the project "Best Process Architecture", a contribution to the BITKOM college competition 2007, the seminar "SOA in Accountancy" held in the summer term of the same year, and the lecture organization-centric "Development of Application Systems", which is an ongoing lecture at TU Darmstadt as of 1996.

Since the problems to be solved in the upcoming years are of an interdisciplinary nature and will have a strong and global impact on the working world, the last section of this paper will include an appeal for global cooperation.

II. ORGANIZATION-CENTRIC DEVELOPMENT OF APPLICATION SYSTEMS

The iterative orchestration of application systems (see fig. 1) is one particular feature of service-oriented architectures in the following aspects:

- The optimized work processes,
- the ideal assignment of employees, and
- the dynamic use of information technology using services.

Services, or more precisely service schemas, are application software that implements work procedures. They are developed on the basis of components and specified as algorithms.

Rather than having oboes, violins or triangles at ones disposal, the orchestration of application systems (see fig. 1) makes use of human beings, organizational structures and technology. Whereby anyone who specifies e.g. organizational processes in the same way as computer processes [4] and does not distinguish between human-related symbol processing and computer-based symbol processing [5], is not suitable for the development of organization-centric application systems. Such a person lacks the interdisciplinary knowledge taught by some of the forward-looking chairs of Applied Computing and Application Systems at universities worldwide.

III. INTERDISCIPLINARY LANGUAGE-CRITICAL SPECIFICATION OF IT-USE

Which skills and what kind of knowledge do developers, i.e. "business architects," "application developers," "solution architects," and so on, need for organization-centric application development in order to successfully participate in projects of this kind or even execute such a project on their own? In his book "Der Flug der Eule" (The flight of the owl, [6]), Jürgen Mittelstraß gives us an answer that is as clearly defined as it is simple:

> "Anyone […] who has not studied interdisciplinary cannot perform interdisciplinary research".

The acquisition of interdisciplinary schemas and the understanding of them is a prerequisite for interdisciplinarity. Anyone who has only studied how to apply something will not be able to develop organization-centric application systems. The following is a simple example that illustrates the profound

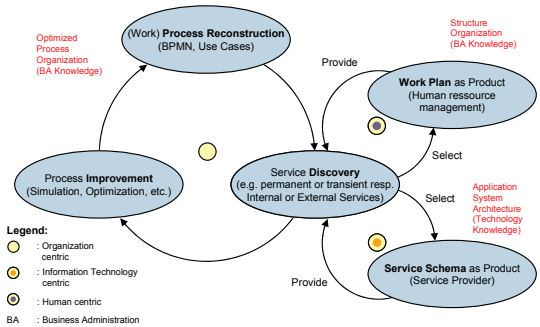


Fig. 1. Iteration paths of orchestration: man - organization – technology

understanding of the development process. The example reconstructs a data schema in Applied Computer Science.

Schematize the following sentence in object-language,

a) "Smith is a customer who is willing to pay."

by means of computer sciences, specifically the meta-language "relational model":

b) "Relation Name (key attribute(s); non-key attributes)"

in an interdisciplinary way, i.e. by different disciplines simultaneously. In order to accomplish this, a developer must not solely understand the sentence in object-language a) with respect to its business-driven generalization (schematization, norm), but additionally, the user must have agreed on the norm derived from it. In our example, this would mean that a society (language community) tolerates the following object-language norm:

a') "If we identify a person as a customer, we are allowed to characterize the customer more closely by the attribute 'payment behavior'."

Furthermore, it is necessary to realize or understand that the "relational model" is merely a different grammar (meta-schema) for representing the standardized (schematized) object-language "content". It is our goal to maintain customer data efficiently on the computer. Through modeling, we achieve the logical result of our interdisciplinary schematization:

b') "Customer (name; payment behavior)".

Interdisciplinary schematization (modeling) is one of the core tasks in Applied Computer Science such as Business Informatics. For the acquisition of interdisciplinary knowledge, e.g. in university courses of study, there is even a so-called "methodical order." We can formulate it as follows, whereby the figures in brackets indicate the "sequence", i.e., the methodical order.

Computer Science:	form (4) follows function (3)
Business Informatics:	applications (3) follow processes (2)

mmeybodi@aut.ac.ir

Business and Social Sciences:	means (2) follow ends (1)

Theoretically, the methodical order, or course can be avoided. However, in practice, it is recommended to adhere to it. It is most advisable to "put on the socks before putting on the shoes", although, at least in theory, it may be possible to consider the reversed order. The problem in some of the programs of study in Computing Sciences is that interdisciplinary knowledge is not taught – even at the recently appointed German superior universities, an apparent lack in IT-architects has lead to the fact that students in bachelor programs of study merely concern themselves with pure computer sciences, i.e. (3) and (4). For those students who have not entered a practical profession by then, the Masters program of study will "ensure that they are acquainted with matters of Applied Computer Science" [7]. Well, it is conceivable that disciplines become extinct!

Modeling is language-based. This is true on the part of object-languages, users, and ends, as well as on the part of meta-languages and the means of computer sciences. The linguistic fundamentals of computer science for modeling have recently been published in [8]. Wittgenstein ([9], § 132) describes the language-critical, practical aspect very well in the following statement:

> "The confusions which occupy us arise when language is like an engine idling, not when it is doing work."

Language works when we are talking with users in the relevant application fields about the development-relevant topics while they are working. The famous linguist Karl Bühler (1879-1963) called this "empractical". Due to their gift for languages, female developers will typically have a natural advantage over their male colleagues in this context. Clearly, interdisciplinarity is much more of a decisive factor for successful projects than mere speaking will be. The author's practical experience leads him to three principles of language-critical development of application systems [10] that are emphasized in the following:

1. Ordinary language is alright. (Ludwig Wittgenstein)
2. Languages have already made a great many, sometimes too many, distinctions. (Paul Lorenzen)
3. We will be held responsible for what we are saying. (Peter Janich)

The first principle shows why development work is practically relevant, while the second emphasizes "engineering" and the foundation of the results with a rational language. The third principle clarifies that the organization-centric development of application systems is interdisciplinary and together with the ends, that is with the ethics as a "critical examination of practical reason" (Kant, 1724-1804), they form the beginning. If we want to evaluate this work, e.g. for later quality management, we must do this one level higher, on a meta-meta-language level. Therefore, we can speak of transdisciplinary, ethic-political education (meta-knowledge) of managers.Both, universities and the industry, or society respectively, are open to a new field of vocational training. However, this will only become possible if researchers and teachers are proficient in their respective fields in an interdisciplinary as well as a transdisciplinary way.

A. Organization Modeling

For successful organization modeling – especially with respect to optimization – differentiation is vitally important. Figure 2 illustrates the possibilities regarding work processes and structures.

The capability to differentiate clearly is critical to the ability to optimize. This is important for the object-language level, the application field, as well as for the meta-language level, the diagram languages or, another grammar. On both levels, the point is the reconstruction of connector words (e.g. to do) and topic words (e.g. to work). On the meta-language level, the developer gets to know the modeling method in greater detail. On the object-language level, the grammar of the modeling language plays a vital role. In the latter case, the organizational expert knowledge of the relevant application domain must be represented in a structured way.

Modeling (topic words of the application field) and structuring (connector words of the modeling language) are different but they supplement each other as complementary parts. We do not approve of the so-called formalistic (only syntax) approaches, as they do not occur in practical use. Even if only one modeling method or one diagram language (e.g. UML) is considered, we are not formalistic but meta-linguistic and use general schematic letters, so-called syntactical variables, for our modeling field (the "content").

In the meta-proposition

> "With one proper name n and a single-figure predicator P, the elementary proposition n ε P is built."

the letters "n" and "P" are syntactical variables. Hereby, "n ε P" is to be understood in such a way that the copula "ε " (read: is a) is a sign of the object language, that forms a link between a particular proper name (e.g. Peter) and a particular predicator (e.g. customer). The copula links object-language "contents" but does not appear between syntactical variables on the meta-language-level.

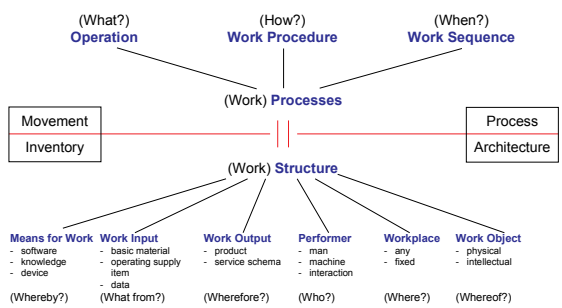


Fig. 2. Differentiated work organization from the position of process and structure

mmeybodi@aut.ac.ir

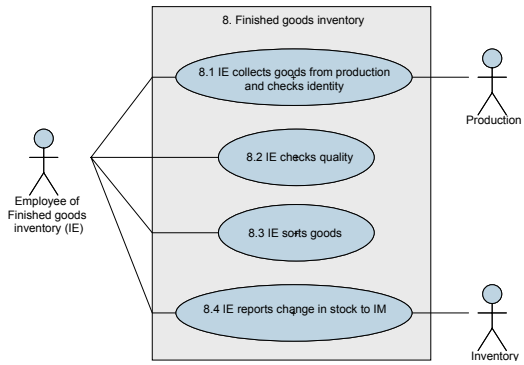


Fig. 3. Use case diagram: Finished goods inventory

Even before the object-oriented system design, diagram languages have proved to be suitable modeling languages for the organization of a company's structures and processes. Use cases for example are especially useful for the structural aspect (see fig. 3), while the Business Process Modeling Notation (BPMN) is suited ideally for the procedural aspect (see fig. 4).

Detailed descriptions of modeling languages can be found in various case collections [11] or OMG manuals. However, anyone who later, in the system design, intends to specify the flow of work processes in greater detail is well advised to distinguish the aspects like "operations", "work procedures" and "sequence of work" or "workflows" orthogonally. The same applies to structural organization and aspects such as "workplace", "vacancy", "employee" or "work material" (see

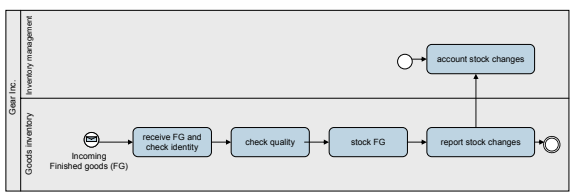


Fig. 4. BPMN diagram: Stock finished goods

fig. 2). The optimization can now be considered sensibly and from different angles (aspects).

B. Method-Neutral Knowledge Reconstruction

The method-neutral knowledge reconstruction [12] is primarily communicative and hardly any diagram representations are used.

In order to get a first picture of the important tasks, which are performed in close cooperation with the users, we classify them roughly in the following three parts:

- Assessment of propositions that are relevant for development by talking to the users.

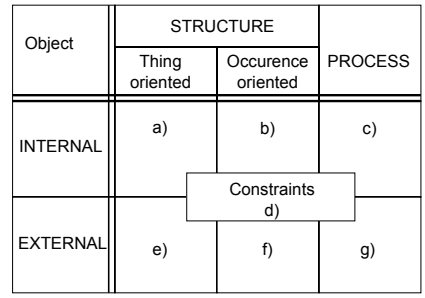


Fig. 5. Classification schema for development-relevant propositions

- Clarification and reconstruction of the expert terminology that has been used.
- Establishment of a common enterprise expert language.

The assessment of propositions relevant to the development can be done by using a model, as shown in figure 5.

The model is intended to aid the assessment and to ensure that all potential types of results for the system design have been scrutinized in consideration of their underlying expert knowledge. The following list contains several propositions that can be assigned to the above fields (see fig. 5):

a) An account has an account number.

b) An account is opened.

c) Opening an account results in an opening balance.

d) The total of all debit line items must be the same as the total of all credit line items in double entry accounting.

e) A (personal) account is assigned to a business partner.

f) Shipment of goods is related to posting business transactions.

g) At the end of an accounting period, all of the accounts are closed, their values are entered in a profit and loss account and ultimately gathered in the balance.

In the clarification and reconstruction of the identified expert terminology the following "defects" are discussed and examined thoroughly with the future users or the company's experts.

1. *Checking* ***synonyms***
   Check for words with the same meaning (extension and intension) that can be interchanged.
   e.g.: MEMBER and ASSOCIATE have the same meaning for DATEV[1].

2. *Eliminating* ***homonyms***
   Check for words that are written or pronounced in the same way but have a different meaning.

[1] DATEV is a computer center and software house for the German-speaking tax profession where the author worked as executive manager in software development for seven years.

mmeybodi@aut.ac.ir

e.g.: STALK, which can mean either part of a plant or to follow someone around

3. *Identifying* ***equipollences***
   Different names are used for the same objects (extension) from different perspectives (intension).
   e.g.: Goods or merchandise of a company is referred to as STOCK from a quantitative perspective and INVENTORY ACCOUNT from a value perspective.

4. *Clarifying* ***vagueness***
   As there is no clear delimitation (definition) of the terms in regard to their content (intension), it may not be clear which objects belong to each term (scope, extension)
   e.g.: Does RESIDENCE, the place where a CONSULTANT works, belong to the term CHAMBERS for DATEV or not?

5. *Replacing* ***wrong designators***
   Discrepancies between the actual meaning of a word and the meaning assumed at first (intension and extension)
   e.g.: For DATEV, the CONSULTANT NUMBER does not define the function of a tax CONSULTANT, but it defines the USER RIGHTS a tax CONSULTANT has within DATEV.

This clarification results in further propositions relevant for development. Their relevance for the result types (system design) can be examined with the help of a classification schema (see fig. 5). Work on building a common expert language for a company, which is aimed at integrating all of a company's knowledge resources, can be organized in different ways.

1. With the help of a repository, a kind of glossary will be created and administered. This glossary will contain all the terms that are important for an organization (language community), and should be designed for internal and external use.

2. A much more complex way, in comparison to (1.), of representing a company's knowledge is with an encyclopedia. The encyclopedia amounts to a conceptual schema for data but will go substantially further in respect to terminological coherences. This approach will distinguish inward and outward knowledge, which will be administered in a repository as an enterprise knowledge base.

3. The enterprise expert language is a rational interim language that is implemented on a meta-meta language level in the repository [13]. It is used for integrating and translating other languages used in the utilized in a company. For users, it is not necessary to know the expert language itself.

Currently, the three variants discussed above can be found in industry worldwide. Vendor-independent research is done in the field of SOA under the catchword *Enterprise Application Integration* (EAI). Furthermore, companies like Oracle look into *Application Integration Architecture* (AIA) and offer products such as Fusion. Other vendors offer products like WebSphere (IBM) or NetWeaver (SAP).

C. Entirely Object-oriented System Design

After the development-relevant knowledge has been reconstructed neutral to specific methods and technology (e.g. according to [12]), and integrated into the overall knowledge base of an enterprise using common language, then, in the system design, this knowledge is transformed into the result types of an object-oriented solution to the task. Figure 6 shows an object-oriented system design according to Schienmann [14] that has been extended for the design of service-oriented architectures.

When we speak of entirely object-oriented development of application systems, the enlightening step is the introduction of objects from computing sciences as grammatical objects. Grammatical objects are target points of language actions (e.g. writing, speaking, thinking), whereby they can also be replaced by pronouns in the sentence (e.g. one, he, him, this one). At school we have learned to speak of direct and indirect objects, genitive objects and various prepositional objects.

In contradiction to what many computer scientists still believe, when modeling and programming in computer science we do not concern ourselves with concrete or "ontological objects" such as this chair, that apple or my laptop. When speaking of objects "informatically" (i.e. modeling and programming in a meta-language), it is of particular importance that abstract types such as "class" in a repository or the term "invoice" in an application, are to be thought of as target points. The concrete, "ontological objects" are usually found in the application fields.

Computer science is the science where students learn how to talk constructively about language (grammatical) objects, or more precisely, about abstract objects. Needless to say, we can still start from the concrete objects of the application fields in "Requirements Engineering" and when introducing the implemented solution, we can refer back to the users' concrete (ontological) objects.

The object-oriented approach in the development of application systems goes back to Platon. Platon classifies

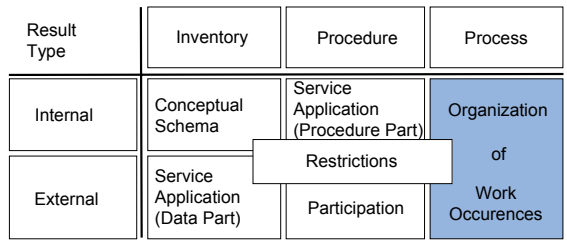


Fig. 6. Extended object oriented system design acc. to [14]

mmeybodi@aut.ac.ir

objects from the perspective of human beings and their languages into things (nouns, proper names) and actions, which can also be considered occurrences (verbs). If we transfer this classification to operating with data on a computer, the object-orientation (resp. its object) will be classified into the fields of data orientation (things) and procedure orientation (occurrences). This classification shows why object-orientation is universal. It encompasses data orientation (data classes) as well as procedure orientation (procedural classes).

Based on the results of organization modeling and system design, the results from figure 6 are modeled in the following order:

1. Process modeling:
   - BPMN diagrams (from organization modeling)
   - State machine diagrams
   - Activity diagrams
   - ...
   - Constraints (e.g. in Object Constraint Language (OCL))
2. Participation modeling:

   Use cases (from organization modeling)
   Sequence diagrams
   Job descriptions (in the sense of structural organization)
   ...
   Constraints (e.g. organizational standards such as signature regulations)
3. Procedure modeling:
   - Class diagrams (data classes and procedural classes)
   - State machine diagrams
   - Activity diagrams
   - ...
   - Constraints (e.g. plausibility checks at data entry in service-oriented applications)
4. Inventory modeling:
   - Object type diagrams (for the conceptual schema)
   - Dataflow diagrams (for specification of data that are exchanged)
   - External schemas (extended as data classes)
   - ...
   - Constraints (e.g. semantic integrity rules for DBMS-enforced integrity)

Organization modeling and the reconstruction of development-relevant expert knowledge from the application fields are highly communicative processes. Here, users and developers communicate very "intensively" (in great detail and clearly) with each other. Diagram languages play a minor role in this context. In contrast, the (entirely) object-oriented design of a SOA with diagram languages must be performed in an already highly "designative" way. This means that the terms of the object language and the meta-language (e.g. error report service as an object-language terminus and procedural class as a meta-language terminus) should be displayed as independent as possible from their use in the judgment-context. The focus is on disclosing the types (software) that shall be implemented later. Diagrams are ideally suited for this purpose.

The diagram languages for procedure modeling are of course very similar to the diagram languages for process modeling. Procedure modeling comprises of the process parts (algorithms), which run as service-oriented applications while a process is being executed, as well as of those process parts, which can be specified in less detail since they involve human work (e.g. following work plans).

The order (1.-4.) chosen here serves merely as a recommendation. The modeling process is an iterative process, as every well-educated developer will know from practical projects (see fig.1).

IV. Concretion in the Large

Organization-centric development of application systems has been derived from data-centric [1] development. The development paradigm "applications follow processes", which is valid in today's service-oriented architectures, complements, but does not replace the data-centric approach. Therefore, SOA stands for a new paradigm, not a shift in paradigm. The data-centric approach remains as important as ever, but due to the triumphant progress of object-orientation and component-based development, it is integrated in the overall architecture and work processes in a more "intelligent" way (Platon was right!). In addition to data processing, work organization (industrial engineering) has become a subject in applied computer science.

Figure 7 illustrates an enterprise that is organized as an application system in a process-centric way, considering the expert field (domain) and the logical position (architecture).

Figure 8 shows an enterprise represented in an entirely object-oriented way. On the right, implementation aspects can be found; the right side lists the specific details of the information technology available for implementation today. We are therefore only talking about a "concretion in the large". "IT and solution architects", "integration developers" and

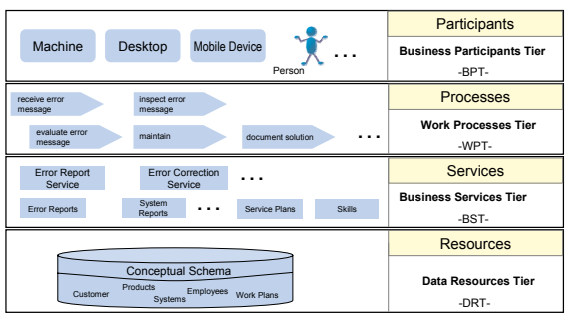


Fig. 7. Tier architecture model of an enterprise as application system

mmeybodi@aut.ac.ir

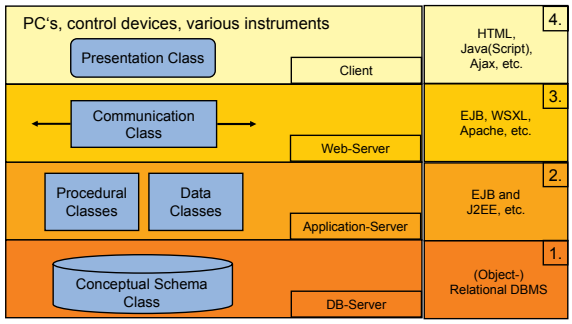


Fig. 8. Entirely object oriented concretion of SOA

"deployment managers" must be able to deliver this concretion for the enterprises (domains) that use information technology.

"Code development", which is of course also important, in particular from the point of view of the "service and solution testers" on site, is currently done in so-called "low-wage countries" by well-trained people (near and offshoring). In complementation to a "concretion in the large", we are now talking about a "concretion in the small."

This sort of *software industrialization* [15] will continue to develop successfully in information technology if enterprises have at their disposal highly qualified „IT-service managers", „IT-operators", „business analysts" and „project managers". It will be shown in the following section, that aside from the software industrialization we will soon encounter a knowledge *industrialization*, which is based, for example, on work plans administered on the net, accumulating knowledge of work execution.

It is advisable to pay attention to admonishers like Mittelstraß when he writes [16]:

> "Knowledge which is only viewed as a good that must be purchased, taught, managed or used, will lose its inherent character, namely to be an expression of the epistemic nature of mankind."

In this context, every country on earth can calculate where its investments would be able to compete, in order to ensure employment and reasonable wealth for its citizens in the future. Given the immense differences in culture, shortages and aggressions in the world, a peaceful competition will be difficult to realize. We would like to refer to the excellent article "Euroskepsis, Markteuropa oder Europa der (Welt-) Bürger"(Euro-skepticism, market Europe or (World) Citizens' Europe) by Jürgen Habermas [17] and in particular to [18] for methodology.

V. Dynamic Support and Optimization of Work Processes

For the dynamic management of application systems (see fig. 7), it is necessary to create and use a meta-information system whose most important part is the repository system [13] as for example described by [19]. In accordance to the much-noted work "The Quest for Resilience" by Hamel and Välikangas [20], future enterprise networks will be implemented as elastic ecosystems [21] built from components of different categories. These systems must be assembled in the best possible way, thereby facilitating the systems to respond, possibly even self-actingly, to changing situations.

The ever changing job design (e.g. due to product changes) and work organization is crucial to this approach. This is done considering

a) the aspects: optimized processes, best possible employee assignment and dynamic IT-support (e.g. IT-services), as well as
b) the fact that some of the jobs that are part of these processes, are performed by employees who come from everywhere, or respectively, the jobs are done where personnel is available at low cost.

In this regard, organizing potential assignments for employees in work plans and establishing a global work base (see fig. 9) is exceedingly relevant. Such a database allows neutral (assignment-free) storage and maintenance. It could contain the IT-services (data and program schemas) that are used anywhere in the world as program-technological means (to work plans) for work in those processes. This way, an enterprise's IT-department organizes and controls the company's work processes worldwide in division of labor and dynamically using the Internet.

The possibility of a global *informatization of our work* as well as an *informatization* of machines arises due to the fact that software (for machines) as well as knowledge (for people) can be managed globally as resources.

Platon (427-347 BC) was also right concerning the core of his ideology. In its modern version based on Frege/Lorenz's abstraction theory [22] the basic verdict reads as follows:

> Abstracta as knowledge or software are assets. This is analytically true.

Software and knowledge represent marketable resources that can be made available and put to use anywhere via the internet

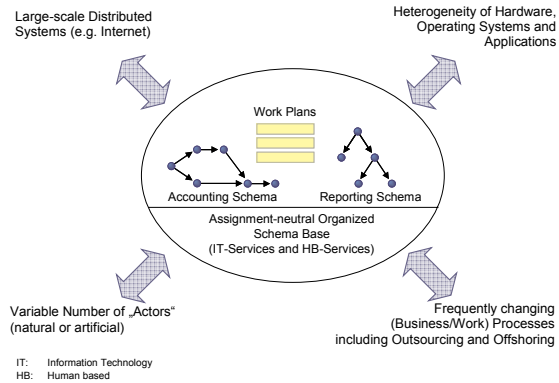


Fig. 9. Worldwide work place management out of the internet

mmeybodi@aut.ac.ir

(see fig. 9). Due to their vital role for the continuously growing human population, they should be treated like assets for which there are various balancing and depreciation rules. While work plans accumulate knowledge, program and data schemas represent software that is used for controlling machines. Knowledge represented in work plans can be considered the resource that offers orientation for human work. It can be traded globally and independently from the executor.

The protruding innovation of SOA is the extension of the concept of application systems by work and organizational processes of enterprises. This makes organization theory as it is found in Business and Social Sciences, the Engineering disciplines or in Industrial Engineering an "integral", that is an interdisciplinary part, of Applied Computer Science. And this in a way that has not been seen in previous years. Concepts and institutions like the German REFA-Association for Work Design or Methods-Time-Measurement (MTM) founded in 1924 (These are systems for time allotment that have been used in Sweden as of 1950, in Switzerland since 1957 and in Germany since 1960) suddenly constitute a field of activity and provide IT-businesses and enterprises worldwide with the knowledge that information and computing scientists possess. Due to Ubiquitous Computing, however, this also affects the courses of study of Industrial Engineering, Business and Social Sciences, Mechanical Engineering, Electrical Engineering or Civil Engineering, as all of them are concerned with work science and process organization.

The following is a list of typical issues in optimization as they were recently elaborated by a student team of the TU Darmstadt at the Bitkom competition "Best Process Architecture" [23].

- *Parallelization*: Operations that are independent of each other must run in parallel and thereby shorten the overall process duration.
- *Optimization of single processes*: In addition, we must analyze each process individually to make improvements.
- *Integration*: Existing systems are integrated seamlessly in the new architecture so that the available resources can be used efficiently and effectively.
- *Elimination of information deficits*: The interfaces between operations are analyzed thoroughly so that the expected input or output will be found at the right time in the right place.
- *Reorganization or sequence optimization*: Process analysis takes into account an increase in efficiency due to reorganization of the order of single operations.
- *Outsourcing*: It is considered an alternative to outsource single processes, especially maintenance activities at the customer's site, to external service providers.
- *Integration*: It is necessary to systematically analyze the overall process for operations that belong together and can therefore be considered a unit.
- *Elimination*: During process analysis those operations must be eliminated that are useless or do not contribute beneficially to the process result.
- *Acceleration*: Specific measures for shortening the overall process duration are vital, but not at the expense of quality and cost.
- *Introduction of additional test steps*: To ensure higher quality, it is useful to integrate additional steps for checking the process.

From the perspective of an employee, there are three possibilities to be considered when setting out to optimize work processes using IT:

1. to reduce people's workload through *automation* (resource: "software")
2. to *support* human work as for example using interactive applications (resources: "software" and "knowledge"), or
3. to improve people's work *qualifications* (resource: "knowledge")

Industrialization and automation were so successful in the previous decades that it is very advisable to revert our efforts with respect to the listing above. With globalization in mind as well as taking into consideration our worldwide division of labor, we should "invest much more in education and as little as possible in further automation efforts." Technological progress cannot be stopped, but a world which is becoming increasingly compact, can only cope with progress, if it is flanked by human education.

VI. OUTLOOK

In Applied Computer Science, from a global standpoint, service-oriented architectures constitute a new paradigm, but do not result in a paradigm shift. Managing data and managing processes are complementary and lead to entirely new job descriptions. In the expert languages of globally interacting IT-enterprises these new professions are called:

- IT-Architect
- Business Analyst
- Application Developer
- Service and Solution Tester
- Software Developer
- Deployment Manager
- Integration Developer
- Solution Architect
- Code Developer
- etc.

Nevertheless, people, who perform these jobs throughout the world, have the least say in *who performs which kind of work when and where*.

Today we are facing a great lack in researchers and teachers at colleges and universities who are able to support young people in acquiring interdisciplinary knowledge. This may be due to the fact that a *systematic uneducation* has apparently made its entry into numerous universities. Liessmann ([24], p. 72) comments this as follows:

mmeybodi@aut.ac.ir

> "Therefore, uneducation today is not an intellectual deficit, not a lack in knowledge, no defect in cognitive competence – although all this will also continue to occur – but it is *not wanting* to understand. Whenever we are talking of knowledge nowadays, it is not about understanding. [...] It is either about the development of technologies that enable us to dominate nature or people or, it is about producing management ratios that have less and less to do with the subject matter it is allegedly about."

Our universities have changed – in Europe for example in the course of the Bologna process – from "Universities of Understood Sciences" to "Universities of Applied Sciences".

What should we do if Liessmann's description of the situation was correct - and practical experience seems to confirm his assessment? This contribution has tried to sketch an answer to this question. There is nothing more important for our survival than that the humanities take up the challenge to newly enter in a process of enlightenment. *Logic*, *Mathematics*, *Linguistics*, *Computer Science* and *Philosophical Anthropology*, for example, are studies of the humanities. "Normative Logic and Ethics" [25] as well as their advancement to an "Encyclopedia Philosophy and Philosophy of Science" [26] provide us with the necessary *fundamental education and terminology*, in the sense of a *Universal Literacy*, to fulfill this task.

Therefore, we appeal for constructive computer sciences to become basic education for all citizens. As a matter of course, this basic education should be graded and differentiated into interdisciplinary (rather universities) and infradisciplinary (rather schools) knowledge. The root of the matter is teaching a disciplined use of language. Anyone who is a democrat and who is interested in participating in remodeling our pluralistic democracies into republics with a "plurality-tolerating form of life" [18] is well-advised to try this in a language-critical way. This form of life is characterized by the fact that it teaches people how they can think correctly instead of teaching them what they should think. – Parlemus!

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mmeybodi@aut.ac.ir

On Translation-Based Design of UML Profiles

Erki Eessaar
Department of Informatics, Tallinn University of Technology,
Raja 15, 12618 Tallinn, Estonia
eessaar@staff.ttu.ee

***Abstract*-The modeling constructs that are provided by the standard Unified Modeling Language (UML) do not allow us to design databases precisely enough. The profile mechanism allows us to extend UML in a lightweight manner. Traditionally, the development of a UML profile starts with the study of methods, platforms or domains for which this profile will be created. In this paper, we propose an additional creation method of candidate UML profiles. This method uses metamodel-based translation and allows us to reuse existing profiles. We use this method in order to create the first version of a database design profile based on existing database design profiles. The new profile allows us to use UML in order to design databases that conform to the rules of The Third Manifesto.**

I. Introduction

UML [1] is a general-purpose modeling language that does not take into account the requirements of all possible environments (methods, platforms, and domains) for which we may need to create specifications [2]. A designer may need a domain-specific language in order to create a specification that takes into account a particular environment.

The abstract syntax of UML is specified with the help of a metamodel [1]. Classes in a metamodel (*metaclasses*) specify language elements. It is possible to extend UML by modifying the metamodel of UML without restrictions or by using the built-in extension mechanism of UML in order to create a new profile. These means are called as *heavyweight* and *lightweight* extension mechanism, respectively. In this paper, we are interested in the creation of *profiles* (UML extensions). The profile mechanism does not allow us to modify the existing UML metamodel. Instead, a profile designer must adapt the existing UML metamodel with the constructs which are specific to a particular environment. Each adaptation is grouped in a profile and is specified in terms of stereotypes, tag definitions (the value of a tag is called as *tagged value*), and constraints.

As a general-purpose language, UML lacks the means for data modeling. However, it is possible to extend UML by using its lightweight extension mechanism in order to permit the creation of conceptual, logical, and physical data models. Guizzardi [3] presents an ontologically well-founded UML modeling profile that can be used among other things in order to create high-quality conceptual data models. Kuzniarz and Staron [4] present a UML profile for creating entity-relationship diagrams. There exist extensions that allow us to use UML in order to create *logical* design models of relational databases [5, 6]. These extensions contain also some stereotypes for representing database objects that belong to the *physical* database level [7] and should be designed during physical design. Examples of these objects are indexes and tablespaces. Marcos et al. [8] propose an extension of UML, the use of which allows us to create logical design of *object-relational* databases. All these extensions to UML [5, 6, 8] have been created based on the SQL standard or systems that use this standard. Additional examples of database-related profiles are the profile of multidimensional modeling [9] and the profile that allows designers to design models of association rule mining during the multidimensional conceptual modeling of data warehouses [10].

The concept "data model" is semantically overloaded. It also means abstract, self-contained, logical-definition of an abstract programming language [7]. This language allows designers to specify the structure and behavior of a set of databases. Each such data model requires accompanying languages and tools that would allow designers to design databases based on this data model. In particular, it is helpful to create high-level pictorial representations of database design. The use of UML for this purpose means that designers can use their existing knowledge about UML as well as development tools that support UML. If we extend UML, then it would be helpful to *reuse* previous work in this field.

In this paper, we consider two data models as an example: the underlying data model of SQL:2003 standard [11] (OR_{SQL}) and the model that is proposed in The Third Manifesto [12] (OR_{TTM}). Currently, there is no common *object-relational* data model and OR_{SQL} and OR_{TTM} are variants of this model.

The *first goal* of this paper is to propose a novel *metamodel-based* method for creating *candidate* UML profiles. A candidate profile is a profile that has not yet been approved or rejected by experts. This method uses metamodel-based translation and allows us to *reuse* existing profiles. The *second goal* of this paper is to use the proposed method in order to demonstrate how to develop a UML profile of OR_{TTM} database design based on UML profiles of OR_{SQL} database design.

The rest of the paper is organized as follows. Firstly, we propose a new method for creating UML profiles. Secondly, we use this method in order to create a UML profile of OR_{TTM} database design. Finally, we draw conclusions.

II. New Method for UML Profile Development

The specification of UML superstructure [1] does not standardize how to present UML profiles to human users. UML specification contains examples of some profiles like

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 144–149.
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mmeybodi@aut.ac.ir

J2EE/EJB Component Profile and COM Component profile that "are not meant to be either normative or complete" [1]. Both Kuzniarz and Staron [4] and Mora et al. [9] describe a schema for presenting UML profiles. A *commonality* of all these specifications is that profiles are specified in terms of stereotypes, constraints that apply to a particular stereotype, and tag definitions. Mora et al. [9] foresee the need of general well-formedness rules that apply to multiple classes.

"A stereotype defines how an existing metaclass may be extended, and enables the use of platform or domain specific terminology or notation in place of, or in addition to, the ones used for the extended metaclass." [1] A tag definition could be attached to any class of a metamodel prior to UML 2.0. In UML 2.0, a tag definition specifies a new property of a stereotype. "A constraint can be attached to any model element to refine its semantics." [9] New constraints must be consistent with the existing constraints of UML metamodel but can be more constraining [1].

Kuzniarz and Staron [4] present iterative stereotype development process that involves "such activities as finding the abstractions, describing them, formalising them and implementing in a UML tool."[4]

In the first section we referred to some data modeling profiles. Additional examples of profiles are the profile of interaction design [13], the profile for software architecture descriptions [14], and the profile for software product lines [15]. The creators of these profiles use existing research about the particular environment as the basis in order to find suitable abstractions and create informal specifications of a profile. Kuzniarz and Staron [4] write that usually formal specifications of constraints are presented by using Object Constraint Language (OCL) [16]. Nevertheless, there are descriptions of profiles [5, 8, 13, 14] that do not present specifications of constraints formally and do not use OCL.

In this paper, we also do not present formal specifications of constraints. We propose that development of a UML profile should not always start from scratch. Instead, a profile designer could search existing profiles and *reuse* them in order to create quickly the first version of the new profile.

A. Preconditions of the Use of the Method

Firstly, we introduce the notation that we use in this paper:

P – the set of *source* profiles, based on which we want to create a new profile. This set cannot be empty; p' – the *candidate* profile that must be created by translating profiles that belong to P; L – the language that is represented by all the profiles that belong to P; L' – the language that is represented by the profile p'. For instance, L is OR_{SQL} and L' is OR_{TTM} in the example in section III. We assume that the profiles in P and the metamodel of L use the same natural language (for example English).

The abstract syntax of a language can be presented by using a context-free grammar or a metamodel [2]. In this paper, we are interested in *metamodels*. The precondition of the use of the method is the existence of the metamodels of L and L' and also the existence of a mapping of elements of the metamodels of L and L'. If a language has more than one metamodel (for instance, they could be created by different parties), then we have to use one of them. We assume that UML has been used in order to create the metamodels. It means that the metamodels of L and L' share a common meta-metamodel. If we create a metamodel by using UML 2.0, then the elements of this metamodel are *classes*, *properties,* and *relationships*. A pair of elements from the different metamodels exists in a *mapping* if the constructs behind these elements have exactly the same semantics or they are semantically quite similar. Ideally, this kind of mappings should be standardized. Similarly to Opdahl and Henderson-Sellers [17], we use a mapping between classes and *do not* use a mapping between relationships and a mapping between properties (attributes).

The use of a mapping between elements of metamodels has been used in order to perform ontological evaluation of a modeling language [17], compare different data models [18], and perform model transformations [19, 20]. In this paper, we propose how to apply this approach in a *new* context.

B. A. Specification of the Method

In this section, we propose a method that allows us to develop the *first* version of the profile p' by using the metamodel-based translation. Firstly, we have to find relevant elements of the metamodel of L and their corresponding elements of the metamodel of L'. After that, we have to use the latter elements in order to construct a candidate profile. Finally, we have to evaluate and improve the new profile. This method uses *horizontal* transformation that involves "transforming a source model into a target model that is at the same level of abstraction as the source model." [19].

This method uses *conceptually* a function that we call as *find_metamodel_elements*. It has four parameters, the names and permitted values of which are:

source_metamodel – the identifier of the metamodel of L;

target_metamodel – the identifier of the metamodel of L';

mapping – the identifier of a mapping between the elements of the *source metamodel* and the *target metamodel*. We need this parameter because there could exist more than one mapping between the elements of these metamodels.

source_metamodel_element – the identifier of an element of the source metamodel (the metamodel of L).

We assume that this function has access to a database that contains specifications of metamodels and mappings of their elements. Every invocation of this function shall produce a result (value) that is a set of identifiers of elements of the target metamodel (the metamodel of L'). The general idea of this function is that for *source_metamodel_element*, it has to find the set of corresponding elements of the *target metamodel* based on the mapping. Discrepancies of the *source metamodel* and the *target metamodel* will cause some problems:

- If an element of the *source metamodel* has more than one corresponding element of the *target metamodel*, then a human expert has to choose *one* corresponding element of the *target metamodel*.

mmeybodi@aut.ac.ir

- If there is a *construct deficit* in the *target metamodel* and an element of the *source metamodel* does not have a corresponding element of the *target metamodel*, then a human expert has to investigate whether it is possible to use *any* element of the *target metamodel*.

As you can see, the bigger are the discrepancies between two languages, the harder it is to translate a profile. Next, we explain the creation method of UML profiles.

Firstly, we have to find the set of profiles P that we want to translate. Translation of profiles involves translation of individual profile elements (stereotypes, tag definitions, and constraints that belong to the profiles that belong to P) by using *find_metamodel_elements*. For each profile element that we want to translate, we have to find the set of classes of the metamodel of L (*source metamodel*) that correspond to this profile element. How can we do that? In case of stereotypes and tag definitions we can find it based on their names. In case of a constraint we have to search nouns from its specification and have to decide in each individual case whether this noun refers to a class of the metamodel of L.

Secondly, in case of each element of the metamodel of L that is found during the previous step, we have to invoke the function *find_metamodel_elements*. The result of each invocation (and possible decisions of a human expert) can be the identifier of an element of the L' metamodel. A profile designer can use it in order to create a new specification of a profile element. It is possible that we cannot translate a profile element of P due to the *construct deficit* in the target metamodel. We do not have to translate constraints and tag definitions of P that are associated with a stereotype *s* that has no corresponding stereotype in p'. We also do not have to translate general well-formedness rules that refer to *s*.

The translation must take into account the evolution of UML metamodel. For instance, the *Core package* of the UML 1.5 metamodel [21] contains class *Method* but the metamodel of UML 2.0 [1] does not contain this class. Let us assume that the profiles in P are created based on the UML version v but p' should be based on some other version v'. For each class in v metamodel that 1) corresponds to the base or parent class of a stereotype in P or 2) is referred by a constraint in P we have to find the corresponding class in v' metamodel by using *find_metamodel_elements*. In case of construct deficit we might not be able to translate a stereotype or a constraint.

The translation must also take into account the evolution of the profile mechanism. For instance, if p' must be based on UML 2.0 but profiles in P are created based on some earlier UML version, then we do not have to translate tag definitions that are not associated with stereotypes.

Finally, we have to validate the new profile in order to accept or reject it and improve it if necessary. Specification of the validation procedure is outside the scope of this paper due to space restrictions.

C. Advantages of the Method

Firstly, the proposed method may allow us to create the first version of a profile more quickly compared to the creation of a profile from scratch (see section III). It is true that we can create p' only based on a metamodel of L' and do not have to use other profiles. However, the proposed method allows us to reuse the wording of existing specifications and information about the base and parent classes of stereotypes. It is especially useful to developers who have not created profiles before.

Secondly, this method can also help expert profile developers. During the translation process an expert has to often intervene and make decisions. Although it prevents full automation of the process it also means that a human expert has to analyze the existing profiles. He/she could find the problems that otherwise would remain unnoticed. Examples of problems are imprecise wording of a specification or the lack of some stereotype, constraint, or tag definition.

Thirdly, it is possible to at least partly automate this translation process. If we want to use existing methods of model transformations [20], then source profiles must have a clearly defined structure. If source profiles are presented informally (like in [5, 8, 13, 14]), then we can try to use read-only scalar string-manipulation operators. They help us to compare substrings from a specification of a profile with the names of classes of a metamodel and replace some substrings with new strings.

Fourthly, this method allows us to track the source of some of the elements that belong to p'.

Finally, the existence of such method could encourage developers to create metamodels of languages and their mappings. Publication and standardization of this information improves general understanding of languages.

D. Challenges of the Method

Firstly, the method requires the existence of metamodels of the languages (L and L') and also a mapping of these metamodels. If we have to firstly create them, then we lose the advantage that the first version of a profile is created quickly.

Secondly, if the quality of a source profile is low, then the quality of the resulting profile is also low. It reduces usefulness of the use of translation process. Lindland et al. [22] present a *semiotic* framework of the quality of conceptual models that involves syntactic, semantic, and pragmatic quality. This framework can be used in the context of profiles as well.

Syntactic correctness is the only *syntactic* goal [22]. Some descriptions of profiles are not syntactically correct because they lack mandatory parts – constraints and tag definitions. For example, Marcos et al. [8] present stereotypes of a profile that could be used during the logical design of a *relational* database. However, they do not present tag definitions and constraints.

Completeness, which is one of the *semantic* goals, means that a model should contain all the correct and relevant statements about the particular domain [22]. It is often not possible to achieve the highest possible completeness of a model [22] (including a profile). However, the relatively low

mmeybodi@aut.ac.ir

completeness of a source profile can negatively influence the result of the translation process. For example, Marcos et al. [8] do not present a stereotype or a tag definition in order to represent *declared local temporary tables*. Therefore, if we use this profile ([8]) in order to create a profile for OR_{TTM} database design, then the resulting profile does not have an element for representing "private relational variables".

The goal of *pragmatic* quality is to make a model as understandable as possible [22]. There are profiles, the specifications of which have relatively low pragmatic quality [5, 8] compared to the more thorough specifications like [9, 10]. For example, description of a UML data modeling profile [5] is a free-form text that does not describe elements of the profile clearly enough.

Thirdly, we cannot completely automate the creation process of a profile. Each discrepancy between metamodels requires the decision of an expert and could prevent us to translate some elements of a source profile. Human experts have to evaluate each candidate profile in order to make sure that all its elements are both necessary and sufficient.

Fourthly, it is possible that a candidate profile that is the result of translation is *incomplete* due to the lack of some stereotype, constraint, or tag definition. It could be caused by the quality problems of the source profile or metamodel. Another reason could be the construct deficit in L compared to L'. It means that the language L does not provide some constructs that are present in the language L'. For example, OR_{TTM} permits the creation of *declarative* transition and type constraints. These constructs do not have corresponding constructs in OR_{SQL}.

Finally, each stereotype can have an associated visual icon. This method does not describe how to modify an icon in order to use it together with the new stereotype.

III. Development of a UML Profile for the OR_{TTM} Data Model

This section contains a case study. A data model is an abstract language [7]. We can use the proposed method in order to design a candidate profile for a data model. Marcos et al. [8] present a UML extension for *object-relational* database design. This extension considers the underlying data model of SQL:1999 as well as the underlying data model of Oracle 8i database system. We use the part of this extension, which concerns SQL:1999 ("the OR_{SQL} profile"), in order to construct a candidate profile of OR_{TTM} database design based on UML 2.0. The OR_{SQL} profile specifies 8 stereotypes: *Structured Type*, *Typed Table*, *Composes*, *REF Type*, *ARRAY*, *ROW Type*, *Redefined Method*, and *Deferred Method*. It is not based on the UML 2.0 metamodel because specifications of some stereotypes refer to classes *Method* and *Attribute*. These classes have corresponding classes *Operation* and *Property*, respectively, in the UML 2.0 metamodel. We use the metamodels of OR_{SQL} and OR_{TTM}, and their metamodel-based comparison that are proposed in our previous study [18]. We call the resulting profile as "the OR_{TTM} profile". The OR_{TTM} profile that is created based on the OR_{SQL} profile is not complete. One reason is that the OR_{SQL} profile does not cover constructs that are traditionally associated with the relational model (for instance, base tables and viewed tables).

Table I presents *some* pairs of classes from the metamodels of OR_{SQL} and OR_{TTM}. There is a name of a class in the column "OR_{SQL}" if this class represents a concept that has a corresponding stereotype in the OR_{SQL} profile. A pair of classes from the metamodels of OR_{SQL} and OR_{TTM} exists in the mapping, if these classes represent language elements that are semantically equivalent or significantly similar.

Construct deficit in OR_{TTM} (see mark "-") means in this case that some classes of the OR_{SQL} metamodel do not have a corresponding class in the OR_{TTM} metamodel. Therefore, we cannot translate the stereotypes that correspond to these classes of the OR_{SQL} metamodel. There are different reasons of the construct deficit. *Ref type* is a set of pointers. The authors of The Third Manifesto argue explicitly against the use of pointers at the *logical* database level and typed tables [12]. However, they are not completely against the use of array types. The second version of the manifest [23] strongly suggested the use of array type generator. This suggestion has been removed from the third version of the manifest [12]. At first glance stereotypes *Composes*, *Redefined Method,* and *Deferred Method* of the OR_{SQL} profile do not have a corresponding class in the OR_{SQL} metamodel [18]. However, we decided that *Redefined method* and *Deferred method* have the corresponding class *SQL-invoked method* in the OR_{SQL} metamodel.

In conclusion, we cannot translate the stereotypes *Composes*, *Typed Table*, *REF Type*, and *ARRAY* in order to use their corresponding stereotypes in the OR_{TTM} profile. It also means that we do not have to translate constraints and tag definitions of these stereotypes.

A. An Evaluation of Candidate Constraints and Tag Definitions

Next, we present *informal* specifications of candidate constraints and tag definitions of the OR_{TTM} profile and evaluate them in terms of the specification of OR_{TTM}. The level of precision of the specification of constraints and tag definitions is the same as in the work of Marcos et al. [8]. We also present original constraints and tag definitions.

The constraint of *Structured Type*: "Can only be used to define value types." [8] The *candidate* constraint of *User-defined scalar type*: "Can only be used to define value types."

The Third Manifesto makes a very clear distinction between values and variables.

TABLE I
MAPPING OF SOME CLASSES OF METAMODELS OF OR_{SQL} AND OR_{TTM}

OR_{SQL}	OR_{TTM}
User-defined structured type	User-defined scalar type
Row type	Tuple type
SQL-invoked method	Read-only operator Update operator
Typed table, Ref type, Array	-

mmeybodi@aut.ac.ir

It states that a database language must not restrict the use of scalar, tuple, and relational types as the types of values or variables. The relational model prescription no. 11 of The Third Manifesto states that the database language D "shall provide facilities for users to define scalar variables."[12] Therefore, we conclude that this constraint is not correct in the context of OR_{TTM} and we remove it from the candidate profile.

Marcos et al. [8] use *Attribute* as the base class of stereotype *ROW Type*. It means that in a UML model this stereotype can be assigned to attributes of classes. A possible reason of this decision is that SQL does not provide a separate statement for creating a row type. Specification of a row type can be part of a specification of a column of a table. On the other hand, we cannot use ROW type as the data type of a parameter of an SQL-invoked routine [11]. The Third Manifesto does not prescribe such arbitrary restrictions. The Third Manifesto states that it must be possible to use any type that is specified in a database in order to define parameters of operators of that type or read-only operators of that type. The use of *Attribute* (or *Property*) as the base class of *Tuple type* does not allow us to specify this kind of operators. Therefore, we think that the base class of stereotype *Tuple type* in the OR_{TTM} profile must be *Class*.

The constraints of *ROW Type*: "It does not have methods."[8] The SQL standard [11] prescribes that definition of a user-defined structured type (but not a row type) can contain specification of methods. The *candidate* constraints of *Tuple type*: "It does not have read-only and update operators." We modified the original constraint by replacing the words that refer to elements of the OR_{SQL} metamodel with the words that refer to elements of the OR_{TTM} metamodel. Other-orthogonal suggestion no. 2 of The Third Manifesto states that definitions of operators "should be logically distinct from the definitions of the types of their parameters and results."[12] Therefore, we conclude that this constraint is necessary in the context of OR_{TTM}. In addition, the same constraint must be used in case of all the stereotypes of the OR_{TTM} profile, which fulfill all the following conditions: 1) it is used in order to specify *types* and 2) its base class is *Class*.

The tag definitions of *ROW Type*: "The name for each element and its data type" [8]. The c*andidate* tag definitions of *Tuple type*: "The name for each attribute and its data type." If we use *Class* as the base class of *Tuple type*, then we do not need this tag definition. The name of a tuple type is *TUPLE{A1 T1, …, Ai Ti, …, An Tn}* where Ai is the name of an attribute and Ti is the name of the corresponding declared attribute type [12]. We can specify attributes of a tuple type by using the name of a class. In addition, we need the constraint: "Tuple type does not have properties".

The constraint of *Deferred Method*: "It has to be defined in a class with children."[8] The *candidate* constraints of *Read-only operator* and *Update operator*: "It has to be defined in a class with children." According to The Third Manifesto, the concept "class" in the object-oriented programming domain has the corresponding concept "data type" (type) in the database domain. As we wrote earlier, specification of a type should not be bundled with the specification of corresponding operators and therefore this constraint is unnecessary in the OR_{TTM} profile.

The tag definitions of *Redefined Method* and *Deferred Method*: "The list of parameters of the method with their data types. The data type returned by the method."[8] The *candidate* tag definitions of *Read-only operator* and *Update operator*: "The list of parameters of the read-only/update operator with their data types. The data type returned by the read-only/update operator." These specifications are not precise enough. Methods in OR_{SQL} and read-only operators in OR_{TTM} do not return a data type but a value that belongs to a data type. Class *SQL-invoked method* has two corresponding classes in the OR_{TTM} metamodel. In OR_{TTM}, both read-only and update operators can have parameters. Only a read-only operator can have a declared type. Update operators are not typed in OR_{TTM}. An invocation of an update operator does not return a value. At least one parameter of an update operator must be subject to update and an argument that corresponds to this parameter must be a variable, not a value. Therefore, we should use different tag definitions in case of stereotypes *Read-only operator* and *Update operator* (see next section).

Stereotypes *Read-only operator* and *Update operator* extend class *Operation* of the UML metamodel. Each *Operation* can have associated parameters according to the UML metamodel [1]. Therefore, tag definitions that represent parameters are not needed in case of these stereotypes.

B. *A Partial Profile of OR_{TTM} Database Design*

In this section, we present *a part of* the UML profile of OR_{TTM} database design (see Tables II, III, and IV). Specifications of stereotypes and tag definitions that were created based on the OR_{SQL} profile are in the Table II and III, respectively. We found all the stereotypes, constraints, and tag definitions by using the metamodel-based translation method. We use the format that is similar to the format that is used in the reference [4] in order to present this partial profile. Data in the column "Base class" refers to model element to which the stereotype is applied (see Table II). Data in the column "Parent" refers to the superclass of this stereotype if this superclass is also a stereotype.

Ambler and Sadalage [6] propose that stored procedures should be modeled using a single class with stereotype *Stored Procedures*. Therefore, we propose to model operators with the help of two classes. One of the classes has only operations that specify read-only operators and another has only operations that specify update operators.

TABLE II
SOME STEREOTYPES OF THE OR_{TTM} PROFILE

Stereotype	Base class	Parent
«User-defined scalar type»	Class	-
«Tuple type»	Class	-
«Read-only operator»	Operation	-
«Update operator»	Operation	-

mmeybodi@aut.ac.ir

TABLE III
SOME TAG DEFINITIONS OF THE OR_{TTM} PROFILE

Tag	Stereotype	Type	Multiplicity
subject_to_ update	«Update operator»	String	[1..*]

TABLE IV
SOME ADDITIONAL STEREOTYPES OF THE OR_{TTM} PROFILE

Description	SQL stereotype	OR_{TTM} stereotype
Base table	«Table»	«Real relvar»
Viewed table	«View»	«Virtual relvar»
Primary key	«PK»	«Candidate key»
Foreign key	«FK»	«FK»
Mandatory column	«Not Null»	-
Unique constraint	«Unique»	«Candidate key»
Trigger	«Trigger»	-
Stored procedure	«Stored Procedure»	«User-defined update operator»
CHECK constraint	«Check»	«Relvar constraint»

The c*onstraints* of *update operator*: "Update operator cannot have the declared type." The *tag definitions* of *update operator*: "The set of names of the parameters that are subject to update."

The c*onstraints* of *Tuple type* and *User-defined scalar type:* "It does not have read-only and update operators." In addition, *Tuple type* has the constraint: "Tuple type does not have properties".

We cannot create the OR_{TTM} profile by only translating profiles like [5, 6, 8] because 1) naturally OR_{TTM} has differences compared to the underlying data model of SQL and 2) existing specifications [5, 6, 8] are incomplete. They present some (but not all possible) stereotypes. In addition, specification of constraints and tags is limited.

However, we present some additional stereotypes of the OR_{TTM} profile (see Table IV). We found them by translating some stereotypes of *relational* (SQL) database logical design that are proposed by Marcos et al [8]. There is a pair of stereotypes if a stereotype in the column "OR_{TTM} stereotype" has been found based on the corresponding stereotype in the column "SQL stereotype". As you can see, we cannot translate some stereotypes (see mark "-"). OR_{TTM} prohibits the use of NULLs in order to represent missing values and therefore all the attributes of a relational variable (relvar) are mandatory. OR_{TTM} does not specify trigger procedures (triggers) because its authors think that all the necessary functionality can be achieved with the help of *declarative* constraints.

IV. CONCLUSIONS

In this paper, we presented a method for creating candidate UML profiles. This method is not meant to replace the existing development methods of profiles but has to *complement* them. This method uses metamodel-based translation. A profile designer could to try to reuse the existing profiles instead of starting development of a profile from scratch. We presented the advantages and the possible problems of the method. We also demonstrated the use of this translation method by creating a partial candidate profile (the OR_{TTM} profile) for designing databases that conform to the rules of The Third Manifesto. In addition, we found that it is possible to use the existing semiotic quality framework of conceptual modeling [22] in order to analyze the quality of a profile.

The future work must include the design, implementation, and evaluation of the complete OR_{TTM} profile.

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mmeybodi@aut.ac.ir

Was Dyslexia Used to Order the Alphabet?

Ernest Hibbs
mailto: emhibbs1@cox.net

Abstract- **Applying four basic visual steps to the alphabet gives us at least two 3D logical structures for representing the visual right and left boundary characteristic of letters. The key characteristics of these structures are also key visual characteristics associated with Dyslexia. Two other matrices are also presented: a 2D matrix from an ox-plowing orthogonal traversal and a transpose matrix. These structures show the combined tightly-coupled, multidimensional, and multipurpose visual properties of the lower-case alphabet. The common properties of letter as flags, triggers, and boundary destinations are presented as candidates for modeling in UML. Conceptual analog letter circuits are used to describe the human complexity and variation in processing directions from the left boundary, the right boundary, and the symmetric letters.**

I. INTRODUCTION

It sounds ironic that Dyslexia may have contributed to the structure of the very alphabet that seems to aggravate Dyslexia. But, what if we are missing the basic creative concepts and structures that may have been meant to assist in teaching the alphabet? When we think of the alphabet, most of us think of a string of 26-letters, not a 3D structure. So, if a multidirectional and multidimensional approach can be found, it may be beneficial to people who process concepts that way.

According to Webster, Dyslexia is "any of various reading disorders associated with impairment of the ability to interpret spatial relationships or to integrate auditory and visual information" [1]. What representation works the best for Dyslexic individuals? In Ronald Davis's book describing the creative aspect of Dyslexia, he makes it known that pictures and graphical concepts associated with the semantics work best. That is the weakness of our alphabet, where "[t]he only picture available is the forms of the letters themselves" [2].

Our approach starts by considering a common problem encountered by Dyslexics – distinguishing between the letters "b" and "d" [3]. The letter "b" is an example of a visual Left Boundary Demarcation Letter (LBDL), where the letter "d" is an example of a visual Right Boundary Demarcation Letter (RBDL). We use the RBDL to go from a 1D string into a multidimensional structure of the alphabet.

Three different types of matrices are presented in this paper: 3D, 2D, and a Transpose matrix. The 3D and the 2D structures can possibly be used for the education of multidimensional learners. The third type of matrix, a Transpose matrix, is used to visually show that the majority of the letters available in the alphabet have an almost perfect upside-down and backwards transpose within the alphabet. This third transpose matrix is meant to show how naturally our alphabet visually encourages a limited number of reversible symbolic letters. The question remains open and the answer is probable that these structures were made under the creative multidimensional stimulation of dyslexia.

For further analysis by engineers, we have possible modeling techniques to describe the problem domain and the potential solutions. The boundary characteristics of these letters and the potential visual actions suggested by these letters align very well with software engineering's method of documenting events in Unified Modeling Language (UML) with sequence diagrams or with state and event traces in Object Modeling Technique (OMT).

Conceptualizing the potential variations to an individual's reading actions is done with a generic engineering circuit component for a letter. In either software engineering or electrical engineering, parallels exist for the directional interpretation of these letters. But first, let us look at the basic steps that help us understand some 3D models associated with the left and right boundary aspects of the alphabet.

II. THREE PREPARATION STEPS FOR 3D

We start with the same set of RBDL recently used as a diagonal in a matrix to decode the QWERTY keyboard as a set of symmetrically selected and symmetrically spaced letter combinations. "Our set of RBDL = {a, d, g, j, m, q, u, y}" [4]. The letter "m" was included although it is a left-boundary letter because it marks both the middle of the alphabet and it marks the change in orthogonal structure and RBDL rate for the rest of the alphabet.

A. Step One – Align the RBDL as EOLN

Our first step is to take the right boundary letters and make them an End of Line (EOLN) marker (or "\n" to C programmers) as if our eyes were parsing to a hard boundary [5].

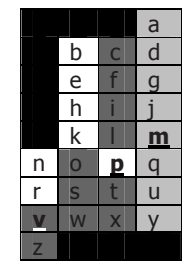


Figure 1. Step One – Align all Right Boundary Letters

What is the result? All except one of the left boundary letters automatically align to the left margin (see Figure 1). In Tahoma font type (selected in the matrices for its simple letter

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 150–155.
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mmeybodi@aut.ac.ir

format) the first two left-right boundary matches are also vertical flips of each other (b-d, e-g).

If that coincidence is not strange enough, look at the center column(s) of the two sub-matrices (4X3, 3X4). These center column letters can be flipped horizontally, vertically or both (as with "x" and "o") and still remain a letter within the center column set of letters. The letters "f" and "t" are very clean horizontal flips of each other.

Even with these items looking like they may have been the result of some planning, there are a couple awkward features that may deter people from considering that this could be a planned structure. At first glance the letters "a" and "z" seem out of place. However, if we look at the letters "a" and "z" as the head and tail, respectively, of a typical linked alphabet list, we have no problem leaving them as the endpoint [6].

Oh no, wait! The letters "p" and "v" are clear exceptions. Or, are these letters markers for the next step of action to transition into a 3D structure? Let us go to Step Two and see.

B. Step Two – Pivot to the offset

Is there a logical reason why the letters "p" and "v" were made such clear exceptions? Yes, they could be pivot indicators. If we think of the alphabet as a multidimensional and multipurpose tool, we could expect some visible hooks or handles into the other structures.

From our left boundary reasoning, where should the letter "p" go? It should be in the location of the letter "v", and vice-versa. So, let us rotate the entire second sub-matrix where it would place the letter "p" in the correct location. Figure 2 shows the result of Step 2.

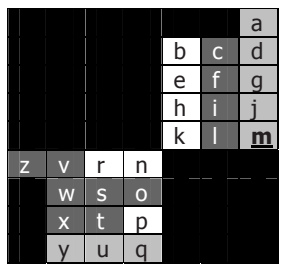


Figure 2. Step Two – Pivot by the Indicators

C. Step Three – Swap the key pivot position indicators

The third and final step is to swap the pivot indicators "p" and "v". We bold and underline these letters to remind us of exceptions to our original letter locations. Now we can use the two orthogonal sub-matrix structures for multiple 3D structures based on the combined properties of left boundary, symmetric, and right boundary alphabet letters. Figure 3 shows this obviously orthogonal set of matrices based on right and left boundary visual characteristics.

Without any further manipulation, these two sub-matrices resemble two hands, with a letter on each knuckle. While that may very well be the key structure used to include additional Latin letters in the Medieval Period, there were other complex influences of calligraphy and the spiritual dimensions of the "Ars Combinatoria" [7]. We will instead proceed to other 3D structures that resemble compilation of alphabet blocks.

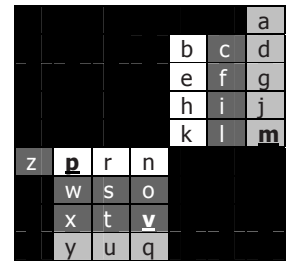


Figure 3. Step Three – Swap pivot indicators

III. FINAL STEP FOUR – POSSIBLE 3-D STRUCTURES

What are these 3D structures? Figures 4 and 5 are laid-out in the form of wrapping paper ready to roll over a cube structure. The case of Figure 4, it is a stack of 6 cubes. In the case of Figure 5, the layout of letters could be wrapped around a cube of 27 cubes, or the easiest method would be to roll the layout over the surface of a Rubik's Cube.

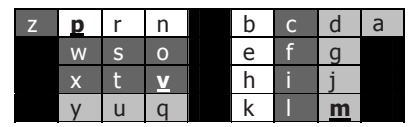


Figure 4. Roll onto a 6-cube stack option

Another alternative to the stack of 6 cubes is a stack of 8 triangles, with the same endpoint (head and tail) letters of "a" and "z". If this was used as a coding device, we could also have one of two triangle-cube combinations. One combination has the first 13 letters in a stack of 4 triangles with vertical stripes accompanied by the second 13 letters in a stack of 3 cubes with vertical stripes. The other combination becomes obvious – with horizontal stripes. The second option has the first 13 letters as 3 cubes with horizontal stripes and the second 13 letters as 4 triangles with horizontal stripes. We are left with a choice, focus on stripe orientation or focus on shape orientation.

Our next structure, the overlay or wrapper for a Rubik's Cube of Cubes, is essentially a stack of 27 cubes with the center cube hidden. The two sub-matrices from Figure 3 are aligned in three columns as the foundational structure for the wrapper. This gives us a clean 26-cube visible configuration. If this structure considered a worthwhile tool, transferring the diagram in Figure 5 to a printable peal-off label to wrap around a Rubik's Cube is a relatively easy task. When we look at the Rubik's Cube of Cubes configuration (fig. 5) our mind may start to wander about the possible manipulations and possible patterns. Are there any other interesting permutations? Yes.

mmeybodi@aut.ac.ir

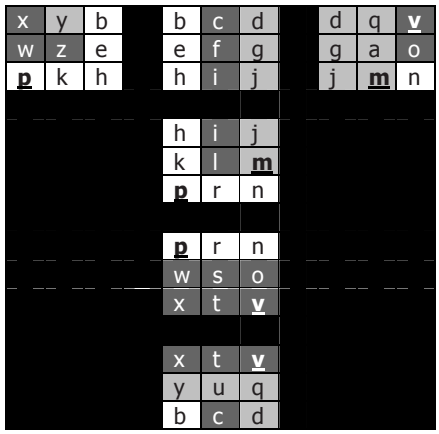


Figure 5. Roll onto a Rubik's Cube of Cubes option

With the first level of right and left boundary letters on top, we can move the "p-r-n" combination on the lower set of nine cubes so we have a pure LBDL-symmetric-LBDL combination on the top level. We do this by rotating the lower platform 90-degrees to the right and then rotating the "p-r-n" 180-degrees. This places "p-r-n" on the top level. It also makes the right side of the cube keep the two columns of RBDLs and gain a complete column of LBDLs.

Another significant configuration is done by starting with the displayed layout and rotating the same bottom 90-degrees the other way (left). This places all the LBDL in one column that wraps around three sides of the cube of cubes. This is the original ordered alphabet matrix ordered, now on the left boundary. The exception is that the letters "p" and "v" have been reversed for graphic presentation and possible original decoding.

IV. 2D MATRIX -- OX PLOWING TRAVERSAL GRAPHIC

The 2D traversal is also orthogonal in that the direction (and the number of degrees) associated with the turn to each RBDL differs between the first and second half of the alphabet. We will use the RBDL as flags, or indicators, for the start of a new path. Imagine the right boundary as a pole and the rest of the letter's body to the right as a flag.

Let us use a logical writing approach (like the ancient Etruscans) for traversing as the ox plows, also called boustrophedon. This alternating travel is left to right and then right to left [8].

As we traverse through the alphabet, please refer to Figure 6, which shows the field with a lighter grey shade, and its perimeter in a darker grey shade. We fill the boxes with RBDL in black with white letters. So, let's get to work.

The first letter "a" marks the beginning of a row. We continue past "b" and "c" to find "d", the beginning of a new row. The ox turns 180 degrees and plows to the next marker. It does not waste effort walking one row only to start a new row over the path it just walked. As a suburbanite, my real life example is cutting the grass in our backyard.

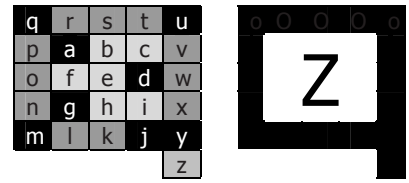


Figure 6. Ox Plowing (a to z) the letters "z" and "a"

At the letter "m", the direction and rate of turns changes. Instead of 180-degree reverse paths, we take 90-degree right turns until the final RBDL. We could then leave "z" as the end, or in our suburban example "z" would be the gate to the yard.

The result is a graphic tracing of "a" to "z" that draws the letters "z" surrounded by "a". What do we gain from this? We get another educational tool that might help multidimensional learners and challenge others to think in more than one dimension. This could also be used as a version of thinking how to draw without "lifting the pencil".

V. TRANSPOSED ALPHABET MATRIX

There is one more thing that helps us understand how a person's eyes can start reading in a different direction: provoked image reversal by an alphabet where almost every letter has a transposed equivalent letter. We create a matrix that flips image of a letter over the vertical line, and then flips over the horizontal line.

s	w	y	t	g
m	**z**	u/v	j	y
h	n	**x**	d	a
f	r	p	**o**	q
b	k	e	b	**l**

Figure 7. The Physically Transposed Alphabet Matrix

A typical transpose of a matrix [9] is a second matrix where the contents of every first matrix location [i,j] is placed into the second matrix into a row-column transposed location [j,i]. In contrast, our matrix in Figure 7 is a transpose of itself. To help envision that reversal, we used our transposed location matrix, where row 4 and column 3 is a transpose of the letter in row 3 column 4. Figure 7 shows a potential transpose of the alphabet from the outside of the body to the inside of the mind. The upper right letters are transposes of the lower left letters, and vice-versa. The center diagonal (where row

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number = column number) contains letters that are transposed back into themselves.

In our matrix, the accuracy of the transpose mapping lessens as we proceed away from the main diagonal. Although most of the letters are represented, the letters "c" and "i" were omitted because a relatively accurate transposed letter for them is not plainly clear.

An example of how the existence of the transposed letter characteristic could confuse a person with Dyslexia is the word "leap". This word would appear as "deal" in Times New Roman font if the reading was being done with a transposed approach.

Unfortunately, this transposing, or double-flipping, of images is not stressed as much as just the single inversion over the horizontal "x" axis. Maybe using vertically symmetric images in lens image inversion demonstrations could be misleading our concepts of light wave propagated images. In one recorded case, some more attention needed to be given to the fact that the "inverted shadow of the tip is seen moving in the opposite direction to the motion of the pencil" [10]. If the light waves move in all directions, an inversion from a converging lens would flip an image over both the "x" axis and the "y" axis after the incident wave fronts go past the focal length [11]. Therefore, this concept of transposing letters may be something to consider for potential cognitive processing characteristics.

VI. EVENT MARKERS, TRIGGERS, AND BOUNDARIES

Event and directional structures that provide efficient and well-defined traversals are powerful tools. Two familiar structures are a typical binary search trees with Per-Order and Post-Order traversals [12] and Turing Machines with a physical tape movement for recording and traversal [13]. Our next question that may come to mind is "how can we determine the direction or logic behind selecting a traversal direction?" If we see the letters as a combination of creative art and logic, the condition of Dyslexia may be induced. What about reading new strings of letters that we know are supposed to be logical words? In our previous example of ox-plowing, we are changing direction based on two items – the middle marker "m" and the change in the stride (distance) between RBDLs only. What happens when we consider both types of boundary letters (RBDL and LBDL) as markers for events?

We have any one of three visual ways to look at a letter; it can be a marker for an undetermined event, a directional trigger for an event, or a boundary for a current event. Figure 8 has a graphic illustration of these 3 visual approaches for the Right Boundary Letters "a" and "d", with Left Boundary Letters "p" and "r".

A. Event Markers, or Flags

An event flag is a marker that some visual traversal direction or method needs to change. The body of the flag is in the same location relative to the flag pole that the body of the letter is to the vertical line of the letter. The flag can designate a beginning, and ending, or a change in direction.

No specific direction of movement is assumed to be beginning or ending. This has many features equivalent to a single tape Turing machine. As a marker on a tape, it can also be combined with other tapes and markers to give direction or annotate a bit to be recorded, as with a Multi-tape Turing Machine having the capability for word reversal [14].

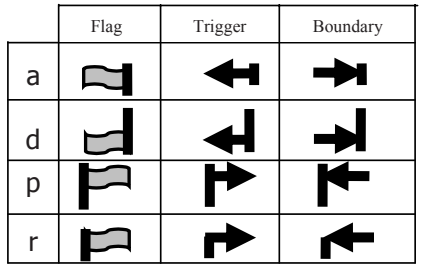


Figure 8. Flags, Triggers, and Boundaries

B. Event Triggers with Direction

We are accustomed to using event triggers to initiate transition for state and event traces in Object Modeling Technique (OMT) [15] and the Unified Modeling Language (UML) [16]. Probably the clearest current visual software engineering parallel is the actions that take place in Sequence Diagrams between objects using UML visual modeling methods [17]. A Sequence Diagram has solid vertical activity lines for every software object involved in a specific sequence or operational scenario. An arrow goes from the lifeline of one object to the lifeline of another object to show an event, message, or transfer of data. Now that we have a combination of the vertical activity line followed by an arrow indicating a trigger and a direction, we also need a terminal description for that activity. Each visually stimulated event movement has an assumed destination, whether in software system events or human reading.

C. Event Boundaries and Destinations

The same RBDL and LBDL can also be seen as being a boundary or destination for the movement of the eye. Note the arrows' direction for the visual representation of the letters in Figure 8. A line with a trigger more readily matches the natural curvature and direction of a letter's body. If the eye's movement is in the direction of the arrow pointing into a boundary (destination) letter's vertical line, the vertical line may be seen as a terminal line. For a software engineering and language parsing parallel, we can also equate this to the indication for exiting from a recursive routine or grammar [18].

At what point do we normally "pop" out of a recursive parsing routing? We exit at the designated syntax point that ends the construction of a word, or the construction of a language phrase built from a grammar. When we read, we visibly complete parsing a word at a designated space or punctuation. Sentences begin with a space before a capital

mmeybodi@aut.ac.ir

letter. We have syntax barrier rules to help make reading more visually pleasant, accurate, and rapid.

The specifically mentioned demarcation purpose and use of capital letters may prove the significance of these demarcation signals and logic. But, what if I receive those signals at the wrong time? Am I at a boundary? Did the word just start, or finish? Am I going the right way? Do the shapes of the letters make sense in the other direction? Maybe a person with dyslexia is mentally using something similar to a working tape to build a word. This mental approach can be equated to using a Turing Machine with auxiliary and working tapes [19].

We cannot err very far if we apply the disciplines of computer science and software modeling disciplines to basic event and boundary characteristics of the alphabet. After all, the most complicated, advanced, and productive research in the power of computing and software languages has been based on Chomsky's hierarchy of languages [20]. Yet, even with the benefits of these disciplines we probably need to think of a generic analog method or model to describe the complexity and the potential influencing factors.

VII. ANALOG LETTER CIRCUIT COMPONENTS

We are analog beings with complex chemical and neurological components, or circuits. Can we develop a small generic schematic circuit that captures both the physical property and the electronic property of a letter's reception? Yes. We use the three letter word "bid" as an example of a circuit-board built on the action-driven properties of the LBDL and the RBDL.

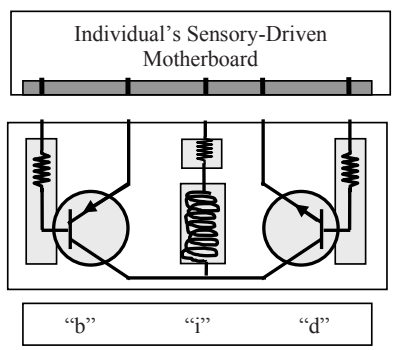


Figure 9. Conceptual Circuit for "b" – "i" – "d" Letter Combination

The first thing to note about the components in Figure 9 is the shaded background boxes behind the components. These shaded boxes have no electronic significance and are merely an attempt to use the visual shapes of the components to have the same as the shapes of the letters. We might as well make the components have a visual stimulation similar to the letters we are trying to describe electronically.

In Figure 9, we use a transistor to depict the conceptual analog controls and flows that occur for an individual focused on the command or direction given by individual LBDL or RBDL. We use a coil (inductor) in our attempts to model the semi-neutral property of the symmetric letter "i". A brief summary of our two types of letter-circuit components may help us understand the amount of potential variability that can occur.

A. Transistors, Gates, and Flows

Note the difference between the transistors in Figure 9. Two types of transistors are used a PNP and an NPN, just because the transistors represent letters facing different directions. The letter "b" is the PNP transistor, with the arrow on the emitter leg pointing into the center of the circle to the base. As you can see, the NPN (emitter leg arrow pointing out) is for the letter "d".

Why was a transistor chosen? It has three elements that that must work together to give the correct directional flow of electricity. While we equate the Base to the boundary demarcation line of the letters (LBDL and RBDL), we equate the Emitter (arrowed leg) to the direction of reading or parsing. We use the parallel connection between the Collectors only to show that the individual components for this specific word ("bid") are in some manner connected to each other.

With this introduction to the circuit, let us review a couple very short general principles of transistor operation. Voltage to the Base, (the vertical line in the circle) acts like a switch that determines how much, if any, current is allowed to flow between the Emitter (leg with arrow) and the Collector (lower angular line in the circle). The transistor must be properly biased. The biasing is done on the motherboard of our circuit. A difference in voltage level between the Emitter and the Collector must exist before current can flow between the two in any direction [21]. The direction of the flow is dependent on the type of Emitter (arrow's direction), and the polarity of Emitter-Collector voltage just mentioned.

So, in our letter-circuit, the (resistor) component added to the connection of both Bases increases the reading resistance. This bias also affects the amount of control and switching by the transistor.

B. Inductive Fields of Symmetric Letters

Now we handle recommending a component for our symmetric and semi-symmetric letters. We need to enter with two assumptions: First, we assume that the symmetric letters are not provoking reading direction reversal; Secondly, we assume that the symmetric letters are more visually appealing and less stressful to the eye. These assumptions can be wrong; it may even be that the symmetric letters are the letters that trigger reading direction reversal. I will have to leave the determination of the accuracy of those assumptions to the experts in the fields of Educational Theory, Cognitive Science, Psychology, and Linguistics.

With our two assumptions, we select symmetric letter circuit components that create more of an attractive magnetic field, such as a coil. We could also select a motor that changes direction with the direction of current flow – but let us keep it simple for now. We also notice our letter "i" has a little visual resistance (small resistor) above it. This small

mmeybodi@aut.ac.ir

resistance is due to the fact that we can only flip or invert this over the vertical "y" axis without losing the letter's form.

C. The Individual's Mother Board

What significance does a standard or generic circuit description have when the human directional reading problems may not be predictable or programmable? A lot! We take the generic conceptual circuit and plug it into the motherboard containing the person's processor. All the motherboard control voltages are determined by how sensitive that individual is to the entire environment. Many of us are affected by food allergies, light, and noise. These are stressors and short circuits to our cognitive processing. These and other short circuits can be amplified by demand for immediate or improved performance. We may not be able to stabilize everybody's life to be at peak processing power (or even the right direction), but we can try to understand and help when possible.

VIII. THE NEXT STEPS

Where next? These concepts are merely the musings of a father trying to make sure he can leverage any educational method to help his child and other children learn. At this point, these tools and concepts are being supplied to experts in Educational Theory, Cognitive Science, Psychology, Linguistics, and other areas of science that deal with optical or cognitive processing. If we can describe and refocus the visually driven capabilities of people, we may also be able to jointly solve problems between what seems to be opposing cultures.

IX. CONCLUSION

Was Dyslexia used to structure and order the alphabet? We cannot say for certain. We can say that obvious graphically-focused methods and thoughts were most likely used to deliberately place boundary and symmetric letters into this specific pattern.

As for our new structural alphabet discovery – use it! Use the three different types of matrices are presented in this paper (3D, 2D, and Transpose matrix) to both educate and to understand. Use the 3D and the 2D structures to assist the education of multidimensional learners. Use the Transpose matrix to help understand some of the potential boundaries and possibilities for the creative multidimensional stimulation of dyslexia.

The disciplines of computer science, software engineering, and electrical engineering provide us with models and circuits that correspond to the visual and logical aspects of using LBDL and RBDL. Further research and cognitive modeling may be most productive if engineers assist with a generic engineering circuit to help conceptualize the potential variations to an individual's reading actions.

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mmeybodi@aut.ac.ir

Construction of Assessments with Double Adaptation Processes

Héctor G. Barbosa León, Francisco J. García Peñalvo, María José Rodriguez-Conde
University of Salamanca, Science Faculty, Plaza de los Caidos s/n, Salamanca, Spain 37008
barbosah@usal.es, fgarcia@usal.es, mjrconde@usal.es

Abstract - **This article presents an authoring tool to construct adaptive assessments covering two aspects: the first one is a proposal to adapt to the learning style of the student by defining links to multimedia material that could be presented to the user and the second one is to adapt the questions presented to the student based on the level of difficulty of each item.**

I. Introduction

In recent years, instructional and educational institutions have been incorporating the assessment activity into their e-learning processes in order to increase the quality, efficiency, and use of this kind of educative platforms [1]. Traditionally, assessment activity has been seen like task aside of the e-learning process and there is a danger in focusing research on assessment specifically [2], as this tends to isolate the assessment process from teaching and learning in general.

According to the Australian Flexible Learning Framework [3], assessment activity, especially when is included within a real learning task or exercises, could be an essential part of the learning experience, giving to the entire Web site the characteristic to adapt itself to the needs of the users.

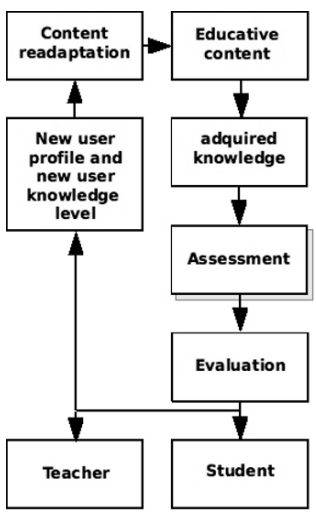


Figure 1. Assessment inside the learning process

In addition, the assessment activity inside the e-learning process could be used to define a new user knowledge level, perform an evaluation process, setting new learning profiles, assign user grades and, in consequence, performing user content re-adaptation [4] (figure 1). For us, the assessment activity after the student took the educative lesson is an element that contributes to the adaptation of the system to the learner needs or preferences as well. We think that, if an item could adapt their presentation to the preference of the user we can reduce the stress because the student may be able to understand the questions more easily and faster. The plan is to adapt the presentation considering the learning style of the students. In addition, we organize each single item into structures to define another adaptation process using a complexity level or item weight which is the traditional adaptation process used by most assessment tools [5], [6].

Nevertheless, those developments started as proprietary tools with their own definition for the items and test. A few of them use open standards and specifications to allow the transference to and from other systems, but this kind of transferences are limited to simple single items, following their definition in the IMS QTI (Instructional Management Systems Question and Test Interoperability) [7].

The rest of this article is organized as follow: in section II we briefly describe the use of open specifications to define the learning objects we want to construct. In section III we present an introduction to the adaptation techniques and how we categorize them in our development. In section IV we explain the adaptation processes we use to construct the test. In Section V, we explain the construction of the final learning object containing an adaptive test with double adaptation processes. Finally, in section VI we present the conclusions.

II. Defining Assessment Items and Exams using IMS specifications

I. Defining items using IMS QTI and IMS CP specifications

The IMS CP (Instructional Management Systems Content Package) [8] specification is used when is necessary to transfer learning objects (lessons, exams or other material) between several Learning Management Systems. In this case we can use this specification to package and transfer assessment items between LMS (Learning Management Systems). In the case of a simple element, the package will contain (a) the manifest (XML file called imsmanifest.xml),

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 156–160.
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(b) the item (QTI XML format file) and, (c) any auxiliary files required by the item.

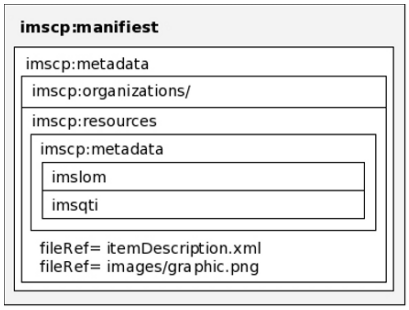


FIGURE 2. IMS LD OBJECT

II. Defining exams using IMS QTI, IMS LD and IMS CP specifications.

The IMS QTI and IMS LD (Instructional Management Systems Learning Design) [9] specifications allow their integration to define a learning object to evaluate the knowledge acquired by the students when interact with an unit of learning (UoL). The IMS LD includes activities of course instruction, modules, lessons and exams in a generic context (those considered as formative assessment) to support the recent knowledge or to give immediate feedback to the student. However, the IMS specifications are used to define learning objects with extra characteristics like adaptation rules for the final presentation and sequence of the questions.

The main structure defined in a IMS LD object is the manifest (figure 2), containing the organization and resources. Inside the organizations section some elements are described, like the roles, properties, activities, environments and methods. The integration of the specifications could be done defining tags and instructions in the *imsld:properties* to control the visibility and order of the elements and the *imsld:conditions* to define decision structures.

The *environments* section is a container for the environment elements, each could be used to describe assessment items for a particular learning style. These structures (the environment ones) could be executed by the LMS in parallel, allowing multiple students of different learning styles to access their own adaptable elements (or an adaptable exam).

III. ADAPTATION TECHNIQUES

Students learn in different ways: seeing and hearing; making reflections and acting; with a logical reasoning process; memorizing and visualizing and by constructing mathematical models. In the same way, the teaching processes vary to make the student to understand better the educative contents and the questions in the summative test. We use the classification of learning styles proposed by Felder [10] and the measurement tool of Index of Learning Styles to obtain the student profile in its preferred learning style.

We can use adaptation techniques and methods [11] to construct adaptive test because we can group items according the associated multimedia material in sections with branching rules to control the access to those sections.

I. Adaptive Presentation

We use the alternative explication because it covers the definition of several versions for one information to show to the user according the preferences stored in the user model. About the adaptation technique, we use the page or fragment variants. Using those definitions in the adaptive assessments, we can make equivalence between the versions of the same information fragment with the different items (which use different multimedia material) that look to cover the same instructional objective. We use the same user model that the LMS to select those items that could perform an adaptation to the user's parameters.

II. Adaptive Navigation

The methods to support the adaptive navigation help the user when she/he is using the web page. Those methods are the global guide, local guide, global orientation and the

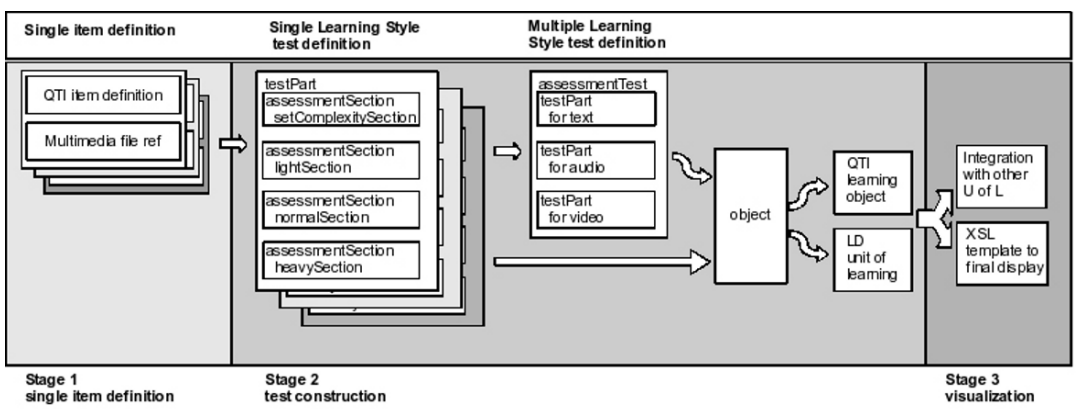


FIGURE 3: CONSTRUCTION PROCESS OF TEST WITH DOUBLE ADAPTATION PROCESS.

mmeybodi@aut.ac.ir

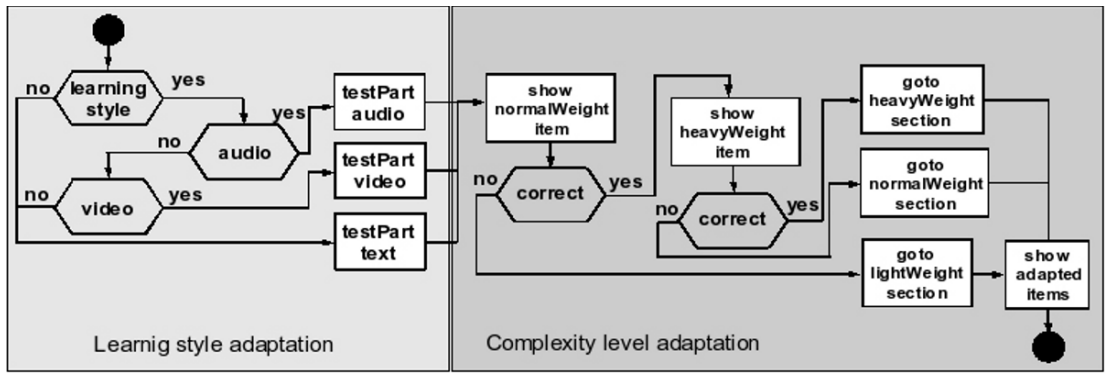


FIGURE 4. ADAPTIVE TEST.

personalized view management. From those, the local guide is the best for us because this method suggests the best next link to follow from the actual node. Talking about the technique, we select the one that hide the links not relevant to the user. When performing a test, we consider the response to the last question to show the next item.

IV. ADAPTIVE PROCESSES

I. Adaptation in the final presentation to the user

The IMS QTI specification allow the developer to define and construct test in which the single items are grouped in several sections which are accessed if some rules are satisfied. We use this specification to adapt the final presentation of each question taking into account the multimedia material referenced from each item.

The QTI specification allows the definition of single questions that include the ItemBody section in which we can refer to external multimedia files. After that, we group the items with the same file format into one section (video, audio and text) know as testPart.

II. Adaptation in the Complexity level

This process look to show the next question taking in consideration the result obtained from the user's response to the last question; if the user's response is right then the complexity level of the new question is equal or higher, if the response is wrong then the complexity level is lower than the last question.

With the IMS QTI specification, we can define instructions to control the presentation of a testPart, section or single item according to the result of a precondition rule, and with conditional bifurcation to another testPart. The precondition and bifurcation labels could be used at any level: testPart, sectionPart, assessmentSection and assessmentItemRef. The adaptation process is defined as follow:

- Definition of a testPart for each kind of multimedia material: video, audio and text.
- Definition of some assessmentSection inside each testPart to group items according their complexity level (high, medium, low), plus an extra medium level item that is showed first to start the adaptation process.

With the preCondition and branchRule labels, we can construct the second process to adapt the test using the complexity level of each question.

The figure 3 shows the construction of test with double adaptation process. First, the learning style of the student is used to select the appropriate testPart. If the user model of the LMS does not store a value for the learning style of the student, then the text testPart is chosen. This is the first adaptation process. The second part start with the selection of an item with normal complexity to begin the response-answer process which will select the best next item considering the response and complexity level of the actual question. Inside each testPart, we define three sections containing items of each complexity levels.

V. ADAPTIVE TEST

An adaptive test is a learning object organized in such way it can be used for compatible LMS to give each student with an adapted test using the parameters stored in the user model. The authoring process allow the definition and construction of different products (figure 4):

- As separate single items that could be referenced by compatible external tools using the IMS QTI specification.
- As complete test that could be used in a session by LMS as a part of a learning activity.
- As a learning object referenced from a learning unit defined using the IMS LD specification in which some conditions are defined to select the testPart using the value stored in the user model.

The elements to perform the adaptation are:

mmeybodi@aut.ac.ir

- User preference: stored in the user model with values of "visual", "audio" or "text.
- Result of the first normal-level question stored in the unifiedResult variable, with values of "Y" or "N". This variable is special because look to unify the result for the different kind of questions (simple choice, multiple choice, etc.).
- The result stored in the following questions in the variable unifiedResult, with values "Y" and "N".



FIGURE 5. CAPTURING A NEW QUESTION

In the authoring process the author select from the list, those items that will be included in the test. The tool shows the items grouped by the multimedia files referenced by them. Once the selection is made, the tool construct the XML-QTI file with the testPart, assessmentSection sections and the reference to the external QTI files for each question and references to the external multimedia files as well. At the end, a file with the IMS CP instruction is generated and packed as .zip format; this file is the one that will be used by the LMS.

Also in the authoring process is possible to define the following kind of test:

- Sequential test: This test does not include branch rules, presenting the questions in the sequential order they were selected from the list.
- Random test: This test does not include branch rules, but the ordering label is set to shuffle.
- Adapted test: This test includes the adaptation rules with the branchRule and preCondition labels to control the items presented to the users.

VI. ADASAT DESCRIPTION

We develop an authoring tool to construct items and test with adaptation characteristics, following open standards and specifications like the IMS QTI, CP and LD and the XML language. The aim is to allow to the author to define items and test using a graphical interface starting form the definition of single questions to the construction of complete test packaged using IMS CP and delivered in a .zip package.

The application cover the following activities:

- Question Construction management.
- Test Construction management.
- User management.
- Test management.

In figure 5, we show the user interface to capture questions. The elements include the title, main statement, question version, categorization and the complexity level of the question, finally, the author select the type of question, including single or multiple option.

In the figure 6, we show the final user interface with a question, including a link to an external multimedia file (in this example a txt file with a text speech for an English language exam), and a group of responses, one of the them is the correct one.

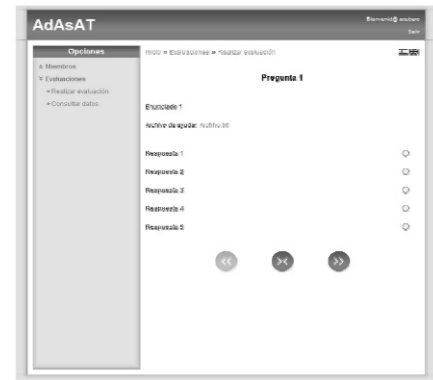


FIGURE 6. TEST PRESENTATION TO THE FINAL USER

VI. CONCLUSIONS

Online assessment is an important step inside the e-learning process, helping to improve the learning and teaching experience.

According to the new developments in the area of e-learning we can see that most of them look to be compliant with accepted standards like the IMS QTI. This gives the convenience to those developments to be interoperable and adaptable to different platforms. In concordance, referring to the assessment activity we can think it must be interoperable as well, because it is one element of the e-learning process and plays an important role inside this experience.

Adaptability is another key factor in assessment. Given the fact that assessment is an important element of the e-learning process and the fact that this process look to be interoperable, then we can think that the assessment tool could be used with different educative content administrator with different conceptualizations and ways to design and apply a

mmeybodi@aut.ac.ir

test for their students. To face this situation it is necessary to develop an assessment tool that could give several ways to design a test with different types of resources, different kind of assessments, group of students, kind of questions, managing schedules, etc.

Under this conceptualization, we created an Adaptive Assessment Tool that could take into account the specific characteristics of educational open systems. This application allows the professor or instructional designer to integrate the test questions, with the supporting media and generate an output file in XML-QTI-CP format. After that, the test could be integrated with other learning activities inside a Learning Management System.

Now we are in the application phase in which we create items to construct a test to evaluate the English level of students. This process start with a Learning Style test followed with the English test itself. At the end of this process, we asked the students to answer a satisfaction questionnaire in which we look to obtain their impressions and feelings about an adaptive test.

We are collecting the data to perform the statistical test to obtain the results to evaluate our hypothesis, which look to evaluate the viability to construct items and test with double adaptation process that help the students to reduce their stress and perform better in an exam.

Acknowledgment

We want to thank to the group KEOPS (ref. TSI2005-00960) of the University of Salamanca for their contributions and ideas for the development of this work.

In addition, we want to thank to the Education and Science Ministry of Spain, National Program in Technologies and Services for the Information Society, Ref.: TSI2005-00960.

Héctor Barbosa thanks the National System of Technological Institutes (SNIT–Mexico) for its financial support.

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mmeybodi@aut.ac.ir

A Study on How Software Engineering Supports Projects Management

Maria-Isabel Sanchez-Segura misanche@inf.uc3m.es

Javier García jgarciag@inf.uc3m.es

Antonio Amescua amescua@inf.uc3m.es

Fuensanta Medina-Dominguez fmedina@inf.uc3m.es

Arturo Mora-Soto jmora@inf.uc3m.es

Computer Science Department, Carlos III Technical University of Madrid
Avda. Universidad, 30, Leganes 28911, Madrid, SPAIN
{misanche, jgarciag, amescua, fmedina, jmora}@inf.uc3m.es

Abstract. This paper contains the results of the study of the following Software Process Reference Models for Improvement Programmes: CMMI, ISO 15504, and the UP, XP, PSP, TSP Methodologies, from a project management point of view. The project management processes analyzed in the above software engineering formalisms were: estimation, planning and quality management. As a result of this study, we offer an overview of the presence, integration, and ease of use of each project management process in the software engineering formalism selected. Results obtained reveal a good degree of integration among processes but a low level of ease of use in most part of the selected formalisms.

I INTRODUCTION

In software project management, an increasingly important, well-developed and well-accepted domain for professional expertise and research, many methods and techniques have been developed in order to ensure the success of projects.

The Project Management Institute (PMI) is a leading a non-profit institution in management standards definition devoted to the dissemination of best practices in project management. This institute has published a standard called PMBOK [1] which can be applied independently of the kind of project to be managed, and proposed a set of processes, tasks and techniques to manage a project properly.

In spite of this, if we take a look at the data on projects in the software field we can see that in 1995, on average, only around 20% of software projects were completed on time and within the budget [2]. What happened to the remaining 80%? These numbers have not changed a lot since then, and many projects still fail to comply with the triple constraints of scope, time and cost [3]. In the words of Steve McConnell, surveys generally indicate that poor project management is one of the top sources of problems in software project development [4]. Many studies have been carried out to identify the reason [5], [6], while others have tried to integrate project management tools with design, programming and testing tools [7], [8].

Since the 80s, the software engineering discipline has been determining the different initiatives of software projects to ensure the quality of the software products under development and there are enough formalisms in the field of software engineering to safeguard the execution of a software project. Why is project management, in practice, still a factor of project failure?

In this work, our goals were:

- to determine whether or not management processes are taken into account into a set of selected software engineering formalisms.
- to analyze the level of integration of software engineering and project management areas.
- to test the level of processes ease of use in order to identify whether this is a possible factor of projects failure.

This paper is structured as follows: Section 2 analyses for each formalism, including Software Process Reference Models for Improvement Programmes and Methodologies the values for presence, integration and ease of use of them. Section 3 presents the results of the analysis and, finally, in section 4 we present the conclusions of this work.

II DESCRIPTION OF THIS STUDY

Our analysis took into account, a set of software engineering formalisms, project management processes and dimensions under analysis for each project management process in each software engineering formalism. There are some other works similar to the one presented here. The one proposed in [9], does not focus on project management processes, and the one presented in [10] focuses on project management processes but the study is very general in the sense of taking into account all the management processes in the same way.

The Software Engineering formalisms selected are catalogued as Software Process Reference Models for Improvement Programmes and methodologies. Our aim is not to compare methodologies and process models among them in project management, but to present the way a methodology or a process model considers the project management and, therefore, what we can expect from them in theory and in practice.

The software engineering process reference models and methodologies selected were:

- Software Process Reference Models for Improvement Programmes; CMMI [11], ISO 15504 [12]
- Methodologies: UP [13] [14], XP[15] [16], PSP[17], TSP[18],[19]. We selected these methodologies because

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 161–165.
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mmeybodi@aut.ac.ir

they are the most cited software development methods in several scientific databases (ACM Digital Library, IEEE Electronic Database and INSPEC Electronic Database) and Google.

We analyzed the following management processes in each of the above methods or process models, taking as the basis the management areas identified in PMBOK, a worldwide recognized project management standard, because these areas can be applied to any project independently of its features (for more information on these processes see [1]):

- Estimation
- Planning
- Quality management

Each management process was analyzed in each process reference model or method according to the dimensions (measured in %) in Fig. 1.. The meaning of each dimension is explained below:

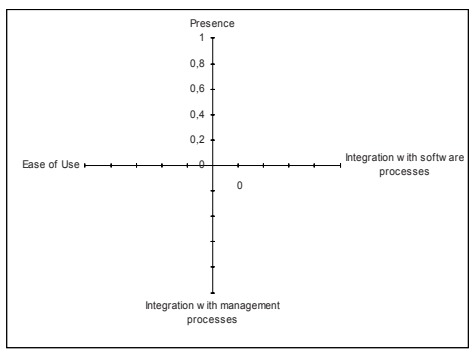


Fig. 1. Dimensions to be analyzed

- **Presence:** as one of the goals of this paper is to determine whether or not management processes are taken into account in some software engineering formalisms, this dimension will be filled in with a value from 0 (no existence) to 100 (highly specified). In this sense, we have assigned the values applying a set of heuristics that are:

  Heuristic 1: No existence (Value assigned: 0)

  Heuristic 2: Activities identification (Value assigned: 25)

  Heuristic 3: Heuristic 2 and definition of the steps or tasks to perform in each activity (Value assigned: 50)

  Heuristic 4: Heuristic 3 and description of techniques to use to achieve the objectives of steps or tasks (Value assigned: 75)

  Heuristic 5: Heuristic 4 and presentation of recommendations or lessons learned to achieve the objective of steps or tasks (Value assigned: 100).

- **Integration:** A low level for this parameter is one of the reasons why projects fail [20]. It is possible that although the management processes are considered in the software engineering formalism under analysis, they are taken into account in isolation. This means that there is no relation with the rest of the software development processes that we called "Integration with *software processes degree"*, or even that the management process is not integrated with the rest of management processes we called *"integration with management processes degree"*. These two dimensions, integration with software processes and integration with management processes, were filled in with a value from 0 to 100 depending on whether the management process under consideration is properly integrated; 100 represents the maximum integration.

  We have assigned the values related to integration with software processes and integration with management processes degrees applying a set of heuristics that are:

  Heuristic 1: No existence (Value assigned: 0)

  Heuristic 2: Process to Process Integration Level, where a process relates to another when an interaction is required (Value assigned: 25)

  Heuristic 3: Activity to Process Integration Level, where an activity relates to another when an interaction is required (Value assigned: 50)

  Heuristic 4: Activity to Activity Integration Level, where an activity relates to other activities of another process when an interaction is required (Value assigned: 75)

  Heuristic 5: Task to Task Integration Level, where a task relates to another task of another process when an interaction is required (Value assigned: 100)

- **Usability**: starting from the hypothesis that "process is itself a product"[21][22], and considering usability as one of the reasons why projects fail, we wanted to analyze for each formalism whether the usability of each process is appropriate. Usability is a quality factor considered in software engineering standards and basically reflects how easy the software is to learn and use, how productively users will be able to work and how much support users need. The usability attribute we are interested in this work is "ease of use", defined as the number of tasks per unit time that the user can perform using the software product where, in this case, the product is a process or a methodology.

  Ease of use is still too difficult to measure because it depends on other factors. In order to measure this parameter, 30 practitioners, with different roles (senior managers (2), project managers (10), analysts (5), designers (5) and programmers (8)) were interviewed after a project management training course where the above methods and improvement approach were explained in detail. We considered all of these profiles

mmeybodi@aut.ac.ir

because they all participate actively in project management, but with different responsibilities and roles. They were asked about their experience in the ease of use of the selected formalisms based on the time required to understand and put into practice these formalisms using the questionnaire than can be reached at http://sel.inf.uc3m.es/documents/projectmanagementstudy.pdf . This URL also includes a summary of the responses given by practitioners surveyed. The responses as well as their correspondence in numbers could be, Very high (100%), High (75%), Normal (50%), Low (25%), Very Low (0%). The formula to calculate the ease of use coverage is:

(#Very High + (#High *0.75) + (#Normal *0.5) + (#Low *0.25) + (#Very Low *0))/#Total.

Neither the comparison among formalisms nor the identification of the kind of projects each standard is suitable for, is part of this study, that is, the description of which standard is better for which project.

III ANALYSIS FROM THE RESULTS OF THE STUDY

III.1 Estimation

Fig. 2 shows the results obtained during the analysis of the estimation coverage in the software process reference models and methods studied. In this sense, we can say that:

- CMMI, UP, PSP and TSP consider this process as an activity. PSP, UP and CMMI recommend several size estimation techniques based on the size of the software to be developed. Only PSP describes in detail the steps and recommendations for this estimation, although this technique is only applicable to small functions, modules or classes.
- In the case of XP and TSP, the estimation activity carried out is considered as an activity, based on the judgment of several experts, using the technique of multiple voting and consensus. For this reason they have a lower degree of coverage.
- ISO 15504 only identifies one activity with a very brief definition of its purpose.
- It is important to note that the absence of integration with management processes between estimation and the rest of software engineering activities is less than expected, because the estimation should be based on a previous analysis of the system being developed and should be redefined as design and construction phases progress.
- Finally, it is important to mention that TSP and XP are the methods considered more usable, because the experts' technique of multiple voting is more attractive to practitioners. This technique, however, is less reliable than applying formal methods, based on historical data, to estimate the size, effort and cost of a software project.

Senior and project managers considered UP, XP and TSP as the easier methods to estimate software projects.

On the other hand, designers and programmers considered XP, PSP and TSP very easy to use. This may be due to the fact that XP and TSP establish as essential the participation of the roles mentioned in estimation activities. PSP is a method focused on individuals, but its ease of use is considered less than the other two (XP and TSP). This may be due to the obligation to complete a set of predefined forms.

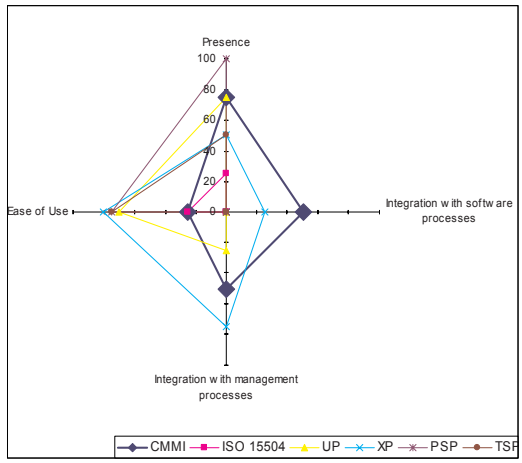


Fig. 2 Estimation Process Results

III.2 Project Planning

Fig. 3 shows the results obtained during the analysis of the project planning coverage in the software process reference models and methods studied. We can say that:

- The activities required to prepare a software project plan (including activities identification, resources assignment and schedule definition) are taken into account in all formalisms analysed. The difference in presence factor is due to the level of detail in the definition. TSP obtained the highest level of presence because it provides the meetings required, the agenda, roles, recommendations and examples. PSP has the highest qualification, but it is necessary to remember that its scope is related to personnel work. CMMI and UP provide the identification of the activities required and recommendations (UP) or links to useful techniques (CMMI) to achieve the objectives of each task. XP presents the "planning the game" practice and gives some general advice for its realization. This is why its score is lower. Lastly, ISO 15504 only identifies ten activities, giving each a very brief definition of their purpose.
- In the case of XP and TSP, several experts, using the technique of multiple voting and consensus, consider planning as an activity, establishing a different perspective for software development project planning.
- The evaluation of integration dimensions reveals poor software processes integration between the planning activities and the elaboration of other plans like configuration management and quality assurance that should

mmeybodi@aut.ac.ir

be much more integrated. The integration of management planning processes with other software engineering activities is also lower than expected, because the selection of the formalism activities to be developed on each project or iteration should be an assisted process in order to select the appropriate activities with enough criteria.

- Finally, it is important to mention that TSP and XP are considered the most usable methods because the process, based on meetings that both of them propose, is very attractive to practitioners. PSP has a lower degree of ease of use because it requires the completion of several forms that the practitioners consider slightly complicated (This may be due to their poor experience or training with this formalism). CMMI and ISO 15504 are considered the least usable approaches because they require adapting and learning many techniques which these models do not propose. The ease of use of CMMI is considered of medium value by the project managers and less usable by the other interviewees (analysts, designers and programmers). Analysts, designers and programmers consider that the number of activities and artefacts to be developed during project planning is very high. This consideration may be due to the lack of training and experience of these roles in project planning practices.

Managers considered UP and XP the easiest methods to plan a software project. On the other hand, the other interviewees (analysts, designers and programmers) considered TSP and XP easier due to the guidelines that enable their participation in the planning activities.

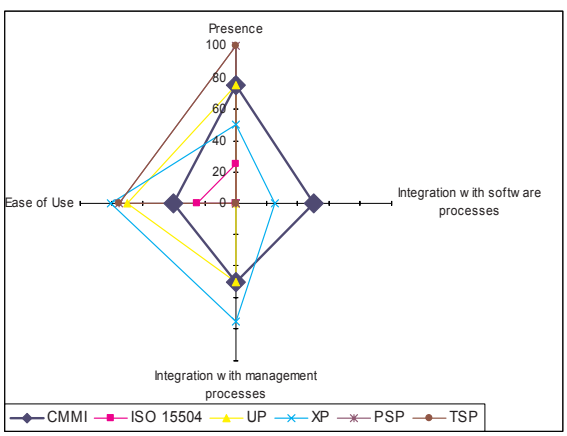


Fig. 3 Project Planning Process Results

III.3 QUALITY MANAGEMENT

Fig. 4 shows the results obtained during the analysis of the project planning coverage in the software process reference models and methods studied. In this sense, we can say that:

- PSP and TSP provide a set of activities, techniques, templates and recommendations for quality management activities, achieving the maximum value for presence dimension. This rich definition also provides a good value for the integration of management processes with the engineering practices, but the users found these techniques difficult for planning and monitoring purposes. Lastly, PSP and TSP have a lower degree of ease of use than expected because they require the completion of several forms that the practitioners and managers considered a bit complicated. This may be due to their poor experience or training in PSP and TSP).
- CMMI and ISO 15504 identify the activities required for process and product quality assurance, but they do not provide a set of tasks to perform, or techniques to apply or recommendations to follow. Although the CMMI engineering process redirects to the quality assurance process when required, the integration with management processes, and with software processes degrees have a low value. In the case of ISO15504, the integration with software processes and with management processes degree is 0 because there are no cross-references between engineering and management processes with quality assurance.
- XP and UP do not consider quality management activities; these activities are only related to source code verification and validation by means of unit, integration and acceptance tests.

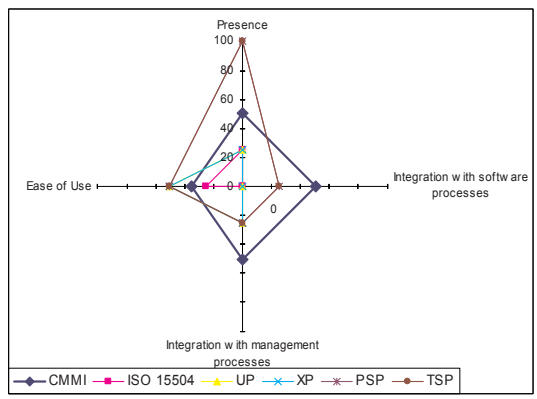


Fig. 4 Quality Management Process Results

IV CONCLUSIONS

Two Software process reference model for improvement programs and four methodologies were analyzed from a project management perspective in order to detect whether or not the selected management processes:

- are taken into account in the software engineering formalisms being analyzed.
- are properly integrated with the rest of management processes and with the development processes.
- have an appropriate value for the ease of use quality factor.

From the results obtained, we can conclude that in software engineering formalisms, in general, the integration among management processes and the rest of the development processes is good, but the main problem for

mmeybodi@aut.ac.ir

practitioners is the low ease of use of software process reference models and methodologies considered.

This gap can be bridged by using software tools that can apply management principles to software engineering formalisms in a blind way for the stakeholders so that the use of management practices can be an easy task to be developed during the whole software lifecycle. Some efforts have been made in this respect but this problem still exists.

Different methodologies and software development standards distribute the project management tasks in different processes defined as necessary for the software development. However, a tendency exists to separate the technical processes (engineering process) from management processes, to define the communication interfaces among these processes according to input and output information, thus creating a dependence on the management processes within the engineering processes.

Further research work related to the support of the integration of standard management process in software engineering projects, and to enable project managers in this decision-making process has originated from the results of this paper. The authors are currently working on the definition of software project management product patterns and the development of the rules that can help managers select the most appropriate practices to manage a concrete software development project based on the characteristics of the organization, personnel and technical restrictions [23] [24].

ACKNOWLEDGEMENTS

This work has been partially funded by the Spanish Ministry of Science and Technology through project TIC2004-7083.

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mmeybodi@aut.ac.ir

Multi-Variant Assignment Generation and Assessment Techniques

G.I. Ankoudinov, I.G. Ankoudinov, A.I. Strizhachenko
North-West State Technical University
5 Millionnaya Str.
St. Petersburg, 191186 Russia

Abstract - Approaches to generation of individualized assignments, based on various diversification models, are considered. The techniques are proposed and discussed for constructing a sufficient number of assignment variants of the same complexity, aimed at increasing their diversity and decreasing the possibility of cheating. The built-in automatic assessment function clears the instructor of the tedious work of looking through a large number of similar assignment papers. On the other hand, automatic self-assessment increases the efficiency of students' home work, reduces the turn-around time, i.e. the duration of the cycle "assessment-correction" after the initial completion of the assignment paper by the student.

I. Introduction

The need for computerized generation of assignments and assessment of assignment papers arises when there is a great number of students studying one course almost simultaneously [1,2]. As far as the instructor corps is concerned, the situation under consideration, firstly, imposes on the instructor a tedious task of composing a great number of variants of assignments which must be of approximately the same complexity and, secondly, lays on the instructor a burden of routine and scrupulous work of checking the papers for correctness, especially papers in mathematical courses, or courses allowing considerable formalization of description. Our more-than-ten-years' experience shows that automatic generation and assessment of students' papers makes instructors' work easier and more effective [3,4,5].

Especially, it refers to part-time university students in the situation of the increasing student-to-instructor ratio. These students usually lack sufficient time for meeting with their instructors. Therefore it is important to make the utmost use of their limited time for consulting with the instructor about the difficulties which may occur in the course of preparing their papers. It would also be reasonable to provide a part-time student with some adequate means at hand, such as a computer program, for automatic checking and self-assessment of the main results of her/his paper so that the student could correct gross mistakes before presenting the paper to the instructor.

One more reason for multi-variant computerized generation of assignments is the principle of "an individual assignment for every student" which is aimed at diminishing the possibility of academic dishonesty, such as copying.

II. Principles of Assignment Generation

The majority of techniques used for multi-variant assignment generation and assessment can be discussed in terms of morphological analysis and synthesis [6]. A compound assignment in the multi-variant situation can be viewed as an object consisting of several parts (functions) forming the set $T = \{T_1, \ldots, T_N\}$, each part T_i having several variants of practical implementation. Therefore a morphological set of assignment variants can be viewed as a Cartesian product:

$$M = S_1 \times S_2 \times \ldots \times S_N,$$

where S_i is the set of alternative variants for assignment part T_i. We assume that $S_i \cap S_j = \varnothing$ for any i not equal to j. This property facilitates generating compound assignments of approximately the same complexity, so as to fulfill the requirement of "equity" with regard to every student, when the elements within one set S_i $(i \in 1:N)$ are not of the same complexity.

The practical implementation of multi-variant compound assignment generation shows that it is important that proper means be employed for the construction of the set S_i for each part T_i $(i \in 1:N)$. The choice greatly depends on the course being taught. There may be the following cases:

1. The course content allows to formulate rather simple rules for constructing alternatives, practically homogeneous and of equal complexity, for the implementation of every set S_i. In this case, any complete variant in $M = S_1 \times S_2 \times \ldots \times S_N$ will be homogeneous and of equal complexity, too.

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2. The course content does not allow to formulate morphological rules to produce the sufficient number of variants of equal complexity. Diversification of assignments in this case can be obtained by using special techniques which allow one to produce outwardly differing formulations (wordings) of essentially one and the same assignment.

III. Assignment Diversification Techniques

We do not dwell on such well-known and widely-used techniques as true/false, multiple-choice and matching quizzes. There is also a popular "table" method of manually constructing individual variants of assignments according to the personal student's code. This approach implies that a compound assignment consists of several parts, every part being represented in a table by several alternatives numbered as 0, 1, …, 9. Each part corresponds to the specified digit of the student's personal code, thus making it possible for the student to choose the variant for every part of his/her assignment. The main drawback of the 'table" methods is evident: the students know each others' personal codes and it opens the ways to copying.

We will focus on the following techniques of multi-variant assignment generation which enable the functionality of assessing freely-constructed solutions, typed in as plain text, in subject areas, based, primarily, on the language of mathematics:

- Diversification of parameter values.
- Diversification of parameter notation.
- Diversification of mathematical formulation.
- Interchange of independent and dependent parameters.

A. Diversification of parameter values

As an example of this not infrequently-used method, consider solving a system of linear equations in matrix form: $Ax = b$. It is quite easy in this case to produce practically unlimited number of variants by generating random values of the elements of matrix A^*, root values x^* and computing the constants $b^* = A^* x^*$. The values of x^* are used for checking the answers.

B. Diversification of parameter notation

The main feature of this approach is that it is based on some initial basic notation for all the parameters of the problem and a manually obtained solution for the notation, adopted as basic. It allows one to obtain a large number of variants for every part of the assignment, differing one from another only in appearance, using various substitutions of parameter symbols. The corresponding substitutions in the manually prepared solution formulation provide the necessary data for automatic assessment of any generated assignment.

The drawback of this technique is that, in some subject areas, such as physics, there exists conventional notation, digression from which is not desirable.

Let there be n parameters in the problem and a set of symbols M, used for denoting the parameters in question, having $m = |M|$ elements, where $m > n$. The total number of notation variants in this case equals the number of permutations of n elements from m: $m!/(m-n)!$. When we generate a sequence of variants for a group of students it is desirable to have these variants as much different as possible.

Consider two permutations of n elements from m: $\bar{p}_1$ and $\bar{p}_2$. Let $\alpha(\bar{p}_1, \bar{p}_2)$ be the number of coinciding denotations in $\bar{p}_1$ and $\bar{p}_2$. Let $\beta(\bar{p}_1, \bar{p}_2)$ be the number of the same symbols being used for different parameters. We propose the following measure of proximity of notation variants $\bar{p}_1$ and $\bar{p}_2$:

$$\rho(\bar{p}_1, \bar{p}_2) = \frac{n - \alpha(\bar{p}_1, \bar{p}_2)}{\alpha(\bar{p}_1, \bar{p}_2) + \beta(\bar{p}_1, \bar{p}_2)}.$$

C. Diversification of mathematical formulation

Diversification of mathematical formulation can be based on special properties of formulae, such as commutativity and distributivity. Diversification of mathematical formulation, combined with the diversification of parameter notation, may be particularly effective for assignments consisting of a series of small problems of the same type. In such cases, one can change the presentation order of these small parts in different assignment variants, together with the diversification of parameter notation.

Example 1. Consider variant 1 of an assignment, consisting of three parts, each part being a formula of propositional logic to be simplified:

Variant 1. Simplify the following formulae

1) $((q \,\&\, \overline{w}) \to \bar{x}) \leftrightarrow (w \to (q \to \bar{x}))$

2) $((\bar{p} \,\&\, r) \to v) \leftrightarrow (\bar{p} \to (r \to v))$

3) $((q \,\&\, \overline{w}) \to \bar{x}) \leftrightarrow (w \to (q \to \bar{x}))$

Let variant 1 be adopted as basic and the following simplified formulae for variant 1 derived manually:

$$1)\ \bar{q} \vee \bar{x},\ 2)\ 1,\ 3)\ w.$$

Then, another variant, e.g. variant 2, may look as follows:

Variant 2. Simplify the following formulae

1) $((v \,\&\, w) \to \bar{x}) \leftrightarrow (v \to (w \to \bar{x}))$

2) $(\bar{p} \to (s \to v)) \leftrightarrow ((s \,\&\, p) \to v)$

3) $((v \,\&\, \bar{p}) \to \bar{s}) \leftrightarrow (\bar{v} \to (\bar{p} \to \bar{s}))$

In this example, to diversify the outer appearance, we have changed the sequence of parts, as well as the notation of Boolean variables: formula 1 in variant 2 is obtained from formula 2 in variant 1 with the help of the substitution $\begin{pmatrix} p & r & v \\ \bar{v} & q & \bar{x} \end{pmatrix}$, formula 3 in variant 2 is obtained from formula

mmeybodi@aut.ac.ir

1 in variant 1 with the help of the substitution $\begin{pmatrix} q & w & x \\ \bar{p} & \bar{v} & s \end{pmatrix}$, and formula 2 in variant 2 is obtained from formula 3 in variant 1 with the help of the substitution $\begin{pmatrix} q & w & x \\ s & \bar{p} & \bar{v} \end{pmatrix}$. Producing formulas of variant 2 in this example, we have also used commutativity of conjunction (&) and equivalence (↔) and, writing the substitutions, we have taken into account logical negation, e.g., substitution of $\bar{p}$ for v implies also substitution of $\bar{v}$ for p. Answers for variant 2, for checking this variant, are derived from the answers of variant 1 simply by means of the respective substitutions:

$$1)\ 1,\ 2)\ \bar{v},\ 3)\ \bar{s} \vee v.$$

Our experience with administering tests in such courses as mentioned in section V of this paper shows the effectiveness of approaches B and C.

D. Interchange of independent and dependent parameters

There exists a rather wide-spread class of problems which can be modeled as a matroid structure [7,8]. To describe such problems, we use the set of parameters $P = \{p_1, ..., p_n\}$ and the set of invertible functional relations Φ, which describe all feasible interrelationships between parameters of the problem. We assume that, from the physical context of the problem, one can find the number of parameters $r < n = |P|$, which is necessary and sufficient for determining the rest $n - r$ parameters with the help of functional dependencies from Φ. Now we will show that the set P under consideration has the structure of a matriod.

One of the definitions of a finite matroid is as follows. A finite set P and a collection of its subsets $S_I \subset 2^P$, called *the independent sets*, is a matriod $M = (P, S_I)$, if it has the following properties:

1. The empty set $\varnothing \in S_I$ is independent.
2. Every subset of an independent set is independent (the hereditary property), i.e. $I'' \subset I' \in S_I$.
3. Every maximal independent set $I \in S_I$ has the same number of elements r which is called *the rank* of M.

A maximal independent set $I \in S_I$, i.e. an independent set which becomes dependent on adding any element of P, is called *a basis* for the matroid.

Denote $\binom{P}{k}$ the collection of all possible subsets of P, possessing k elements. Then the set of all the bases of a matriod will look this way: $S_I^b = S_I \cap \binom{P}{r}$. Then we can use some basis $I \in S_I^b$ as the set of independent, i.e. "known", parameters of a problem and use the dependant subset $D = P \setminus I$ as the set of dependent, i.e. "unknown", ones, the total number of all possible assignment variants being equal to $\left|S_I^b\right|$.

To construct the set of all bases S_I^b and the set Φ, we use the definition of the matroid, based on the concept of a matroid circuit [7,8], which is defined as a minimal dependent subset of P, i.e. a dependent set, the proper subsets of which are all independent.

The collection of circuits $S_C \subset 2^P$ has the structure of a matroid if

1. Any proper subset of a circuit is not a circuit.
2. If C' and C'' are circuits, $p \in C' \cap C''$, then $C' \cup C'' \setminus p$ contains a circuit.

We will define a set of basic circuits $S_C^b \subseteq S_C$ this way: every circuit $C_j \in S_C^b$ is a set of parameters $C_j \subset P$ in the subset of functional dependencies $\Phi_j \subset \Phi^b$, described, at the beginning of the analysis of the problem, by the independent relationships that look this way: $\varphi_j(C_j) = 0$. If $S_C^b \subset S_C$, one can expand S_C^b to S_C, using the second statement of the matroid definition in terms of circuits, given above.

Example 2. A closed electrical circuit consists of a cell, with emf e and internal resistance r_1, and a resistor with resistance r_2, connected in series. Let i be the current in the circuit, u_1 and u_2 be the voltage drops on r_1 and r_2, respectively.

In this example we have: the set of parameters $P = \{e, u_1, u_2, r, r_1, r_2, i\}$; the set of basic relationships Φ^b:

$\varphi_1(e,i,r) = e/r - i = 0$, $\varphi_2(u_1,i,r_1) = u_1 - i \cdot r_1 = 0$,

$\varphi_3(u_2,i,r_2) = u_2 - i \cdot r_2 = 0$, $\varphi_4(e,u_1,u_2) = u - u_1 - u_2$,

$\varphi_5(r,r_1,r_2) = r - r_1 - r_2 = 0$;

the set of basic circuits S_C^b: $\{e,i,r\}$, $\{u_1,i,r_1\}$, $\{u_2,i,r_2\}$, $\{u,u_1,u_2\}$, $\{r,r_1,r_2\}$.

In the example under consideration, the rank equals three $(r = 3)$ and, to construct the set of bases S_I^b, it is sufficient to select all the triplets in $P = \{e,u_1,u_2,r,r_1,r_2,i\}$, the combinations of which do not appear in S_C^b:

$$S_I^b = \{\{e,u_1,r\},\{e,u_1,r1\},\{e,u_1,r_2\},\ ...,\ \{r,r_1,i\},\{r,r_2,i\},\{r_1,r_2,i\}\}.$$

IV. Sequencing Assignments at the Output

When one designs an algorithm for generating assignments, it is important to ensure the proper order of assignments appearing at the output so that variants with close numbers look sufficiently different. Let $V = \{0,1,\ldots,n_V\}$ be the set of subscripts, determining the order in which assignments are generated. As a rule,

mmeybodi@aut.ac.ir

variants with close subscripts do not differ considerably. Moreover, variants with the neighboring subscripts v and $v+1$ are only minimally different. In every particular case, we can introduce a function $\rho(v_1, v_2)$, such as given in section B, measuring the degree of difference between two variants $v_1, v_2 \in V$. A variant $v \in V$ of assignment for each student is given by means of a function $f_v : T \to V$, where $T = 0,1,\ldots,t_{\max}$ is the set of subscripts, determining the order of assignments at the output. Then the value of $t \in T$ can be used as the number of an assignment variant.

Suppose we have a group of n_g students, whose personal codes do not form an interval of consecutive integers, then we can use the personal code of each student as t and the number of his/her assignment is determined by the following function:

$$f_v(t) = t \bmod n_V,$$

where $n_V = |V|$.

Still, sometimes a group of n_g students are given a consecutive sequence of variants t_0, t_0+1, …, t_0+n_g-1. In such cases, an approach to constructing f_v can be based on the following reasoning. When t varies from 0 to $t_{\max}$, function f_v has to provide the value of $\rho[f_v(t), f_v(t+1)]$ as large as possible. A sufficiently "randomized" sequence of assignment variants at the output can be obtained, if one uses, in the capacity of f_v, a function having the sequence of values $f_v(0), f_v(1), \ldots, f_v(t_{\max})$ which is fixed, pseudorandom and bounded by the value of n_V:

$$f_v(t) = f_{PR}(t) \bmod n_V,$$

where $f_{PR}(t) : T \to T$, the sequence of values $f_{PR}(0)$, $f_{PR}(1)$, $f_{PR}(2)$ … is fixed, pseudorandom and bounded by $t_{\max} > n_V$.

V. Practical Implementation

The techniques, described above in section A, B, and C, have been practically implemented as dedicated computer programs, listed in Table 1, and are being used at NWTU since 1995 (see, e.g., http://www.nwpi.ru/if/vmksis.html [in Russian] and http://bigvilly.chat.ru/ankoudinov.htm [in English]). The common feature of all these programs is that they are written in Pascal, run under DOS, and have no external databases, all specific data for each course having been built into the respective program. What they also share in common is a set of universal functions and procedures used for generating all the necessary permutations, combinations, and substitutions of parameters, and sequencing assignments at the output.

Interchange of the "knowns" and the "unknowns" based on matroid structures, described in section D, has been realized in an experimental program MatrTest which runs under Windows and uses an external dataset for any particular problem.

Example 3. Consider the classical problem of two boats starting at the same time from points A and B to meet each other. An example of dataset for this problem, written as plain text file 'boats.txt', looks as follows:

```
mode    debug
rank    4
text
   A boat starts downstream from A to B.*
   Another boat starts at the same moment from B to A. *
end
param
   v1r mph is the speed of the boat with current starting from A // *
   v2r mph is the speed of the boat with current starting from B // *
   L1 miles is the distance from A to the point where the boats pass
each other  // *
   L2 miles is the distance from B to the point where the boats pass
each other  // *
   L miles is the distance between A and B // *
   t hours is the time when the boats pass each other
   // 2    3    4    5    6 *
   v1 mph is the speed of the boat in water starting from A
   // 3    3.5    4   4.5 *
   v2 mph is the speed of the boat in water starting from B
   // 3    3.5    4   4.5 *
   Vr mph is the speed of current // 0.5   1     1.5     2 *
end
calc
   v1r    $+   v1   Vr *
   v2r    $-   v2   Vr *
   L1     $*   v1r   t *
   L2     $*   v2r   t *
   L      $+   L1   L2 *
end
cycle
   v1r    v1   Vr *
   v2r    v2   Vr *
   L1     v1r  t *
   L2     v2   r t *
   L      L1   L2 *
end
end.
```

In this example, we have a matroid of rank 4. The common part of all variants of assignment formulations is placed between keywords *text* and *end*. Denotations of all parameters and their definitions are placed between keywords *param* and *end*. Alternative numeric values of parameters v1, v2, v1r, v2r, Vr, L1, L2, and t are given after '//'.

TABLE 1
EXAMPLES OF PRACTICAL IMPLEMENTATION IN DEDICATED PROGRAMS

Course	Program
Discrete mathematics	DM95.exe
Mathematical logic and theory of algorithms	MLTA96.exe – MLTA2005.exe
Theory of automata	TA96.exe
Numeric methods	CHM95.exe

mmeybodi@aut.ac.ir

The rest of the parameters are calculated using the functional dependencies described between keywords *calc* and *end*:

```
v1r  $+  v1   Vr * ...  L     $+   L1  L2 *
```

An interpreter, built into the program, calculates these statements as the following formulae:

$$v1r = v1 + Vr, \ldots, L = L1 + L2.$$

The cycles of the matroid for this problem are listed between keywords *cycle* and *end*. 75 different variants of independent and dependent parameter combinations can be used in this problem. Using the alternative parameter values in the file 'boats', we find the total number of variants: 75×5×4×4×4=24000.

The statement *mode debug,* at the beginning of the dataset in this example, means that the program operates in the 'debug mode', i.e. the values of the unknowns are given in assignments for the purpose of debugging.

For instance, variant 120 looks as follows:

MatrTest - Variant 120.
A boat starts downstream from A to B. Another boat starts at the same moment from B to A.
The following data are known:
* the speed of the boat with current starting from B v2r = 1 mph
* the distance from B to the point where the boats pass each other L2 = 4 miles
* v1 mph is the speed of the boat in water starting from A v1 = 3,5 mph
* the speed of current Vr = 2 mph
Data to be found:
v1r mph – speed of the boat with current starting from A (= 5,5); L1 miles – distance from A to the point where the boats pass each other (= 22); L miles – distance between A and B (= 26); t hours – time when the boats pass each other (= 4); v2 mph – speed of the boat in water starting from B (= 3).

VI. Analysis of Computerized Self-Assessment Effectiveness

To analyze computerized self-assessment effectiveness, we use the model of iterative processes [9] for the "assessment-correction" cycles (Fig. 1).

In this model, T_0 is the mean time of assignment's initial completion; T_1 is the mean time of assignment's assessment in one iteration; T_2 is the mean time of assignment's correction in one iteration; p_i is the probability of the i-th entrance into the correction cycle.

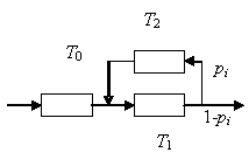


Fig. 1. Model of the iterative "assessment-correction" cycles

We assume that p_i is decreasing with every new cycle and use the following approximation: $p_i = p_1 e^{-(i-1)\alpha}$ $(i = 1, \ldots, n)$, where $\alpha \geq 0$ is the coefficient which specifies the decrease in the probability of entering the iteration cycle. If one has gathered statistics for p_1 and p_2, then $\alpha = -\ln(p_2 / p_1)$.

The mean time T of the iterative completion of the assignment can be evaluated with the following formula

$$T = T_1 + p_1 \frac{T_1 + T_2}{1 - e^{-\alpha/2} p_1} = T_1 + p_1 \frac{T_1 + T_2}{1 - \sqrt{p_1 p_2}}.$$

Self-assessment reduces considerably the value of T_1.

Conclusion

A classification and outline of multi-variant assignment generation and assessment techniques, aimed mostly at mathematics-based problems, have been made. These include, besides the well-known approaches, the techniques of diversification of parameter notation and mathematical formulation which the authors have been using for more than ten years. A novel approach, namely, the interchange of independent and dependent parameters, using matriod structures, has been proposed. The importance of proper sequencing assignments at the output of the generating procedure has been stressed. The iterative model of "assessment-correction" cycles for evaluating the turn-around time has been offered.

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mmeybodi@aut.ac.ir

Critique of Traditional Statistical Tests in Asset Pricing Models*

Hai Lin
Department of Finance and Wangyanan Institute for Studies in Economics (WISE), Xiamen University, Xiamen, 361005, China

Abstract: This paper address the impact of estimation bias on the use of traditional statistical tests in testing time series asset pricing models. Since we have no ideas about the true risk factors but only use some linear portfolios as their mimicking, these representatives themselves include noise term that will affect the estimation and result in the estimation biases. Due to the fact that traditional statistical tests have no power to check whether the significant correlation comes from useful risk information or useless noise information, they are not robust as the benchmarks for evaluating different asset pricing models. These results are shown in simulations.

I. INTRODUCTION

How to explain the tradeoff between risk and return is a longstanding problem in finance. Ref. [1] and Ref. [2] do pioneering work and propose Capital Asset Pricing Model (CAPM). This model states that there is only one risk-market risk and the risk premium of stocks are only related to their systematic market risk (beta). CAPM is a simple and intuitive theory for explaining the risk-return tradeoff. Since then, testing of CAPM has never stopped and given birth to a large number of other asset pricing models.

Ref. [3], Ref. [4] and Ref. [5] test the CAPM in time series and found the relationship between beta and expected return is too flat to be explained by CAPM. Ref. [6] proposes the CAPM with lending constraints to explain such phenomena.

However, a lot of later empirical tests show that the some changes of stock returns are not related to market risk but to some firm characters, such as size, BM and E/P. Such phenomena are called "abnormalities" of stock market since they could not be explained by traditional asset pricing theories. New theories were then proposed to explain the abnormalities. They can be divided into two broad categories.

One is behavior finance theory. Ref. [7], Ref. [8], Ref. [9], and Ref. [10] state that SIZE and BM are not risk factors but firm characteristics that reflect some firm fundamentals. High BM firms are value firms and low BM firms are growth firms. Because the investors are overreacted to the historical performances, they prefer low BM firms, resulting in the high price of low BM. This overreaction will be corrected in the end. The high BM then gets higher return than low BM.

The other is to consider more complicated models within the classical rational pricing framework by relaxing some strict assumptions, such as ICAPM by [11], CCAPM by [12], CCAPM with habit by [13] and the Stochastic Discount Factor (SDF) model by [14].

Among all the new models to explain the change of stock returns, Ref. [15] and Ref. [16] are the most popular models. They proposed another two risk factors-SIZE and BM to explain the abnormalities of stock returns. The risk premium of SIZE is represented by the return of small size portfolio minus the return of big size portfolio (SMB), while the risk premium of BM is represented by the return of high BM portfolio minus low BM portfolio (HML). The strong evidences of explanatory power for their model include: (1) the statistical values, such as t statistics, show that the parameters of HML and SMB are significantly different from zero; (2) When regressing returns of different portfolios on market index, some intercepts are significant different from zero. However, after the introduction of HML and SMB, most of the intercepts become non-significantly different from zero.

Since many risk factors, such as macroeconomic factors, are unobservable from the market, mimicking portfolios for economic factors become important for both asset pricing theories and empirical work. There have been a lot of studies that use mimicking portfolios. Some use mimicking portfolios for some economic factors, such as [17] for aggregate consumption growth, [18] for some macroeconomic factors, [19] for pre-specific macroeconomic factors and [20] for state variables in multi-beta model. Ref. [21] and Ref. [22] use mimicking portfolios to make inference about the asset return predictability related to some risk factors.

As a result, the asset pricing tests nowadays are mainly focused on explaining the abnormalities from the estimation by mimicking portfolios. A model with significant betas and non-significant intercept is considered to be a good model for explaining the stock return. However, few are concerned with the estimation bias problem. If the estimation is biased, the abnormalities in previous regressions are not the real abnormalities and they are not robust as the evidence of rejecting CAPM and accepting new pricing theories.

Unfortunately, this estimation bias is possible to happen when we test the time series asset pricing models. This is

* The paper was finished while the author was visiting Cornell University, USA and Singapore Management University, Singapore. The author thanks the financial support from Wangyanan Institute for Studies in Economics (WISE), Xiamen Univerisity. Contact Information: Hai Lin, Department of Finance, Xiamen University, Xiamen, 361005, China. Phone (Fax): 0086-592-2186976. Email: cfc@xmu.edu.cn.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 171–174.
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mmeybodi@aut.ac.ir

mainly due to the fact that we have no idea of expected return of the true risk factor but rely on some linear portfolio of stocks as its mimicking. Such a mimicking portfolio includes noise itself that will affect the estimation. Moreover, if the noise is related with the stock return, the estimated beta will be different from zero even if the true beta is zero. As a result, the estimated parameters are biased and are not robust for testing the asset pricing models.

The estimation bias is in fact also a general problem in financial research, especially when we use some observed data as the substitution of unobserved data. Ref. [23] found that the use of averages on independent data can generate correlation between averaged data. As a result, even if the true data is independent, when we run auto-regression on averaged data, the AR coefficients would be significant. Ref. [24] finds the correlation caused by non-synchronous trading, i.e., when the true continuous compounded returns follow independently and identically distributed (i.i.d.) but if we use the other computed returns as their estimation, we would get the following biases: (1) serial correlation in estimated return; (2) variances over estimated; (3) contemporaneous covariance under estimated. In another research, Ref. [25] also proposes that the bid-ask effect affected the estimation of size effect. After considering the bid-ask effect, the size effect was only half as large as [26] reports.

When testing the asset pricing models in time series, we often use some linear portfolios of stock returns (for example, market index, SMB and HML are all portfolios of stock returns with different weighting methods) as the representatives of risk factors. The returns of these portfolios have their noise term. The estimated betas capture not only the useful correlation between risk factor and stock returns, but also the useless correlation between noise and stock returns. It may be very difficult to separate the useful correlation from useless correlation to get the efficient estimators. As a result, we have no ability to test whether the linear portfolios imply some useful risk information by traditional significant tests since they may come from nonzero correlation between noise and stock return while the correlation between risk factor and stock return is zero. Then, traditional statistical tests, such as t tests, F tests and likelihood tests, are not robust in checking the correct risk information.

Ref. [27] and Ref. [28] also question mimicking portfolios in testing asset pricing models. Compared with their studies that just tell about the truth, we try to find out the source of estimation bias and make it more theoretically robust based on a simple econometric convergence analysis. In section 2, we theoretically propose the estimation biases when we use linear portfolio of stock returns as risk factors to test asset pricing models in time series. In section 3, we show the theoretical results by simulation. Section 4 concludes.

II. Model

Consider the Stochastic Discount Factor Model

$$E\left(mR_i^e\right)=0 \tag{1}$$

where m is the SDF, R_i^e is the excess return of asset i.

Then

$$E(R_i^e)=-\frac{1}{E(m)}\mathrm{cov}(m,R_i^e) \tag{2}$$

In real time series regression, it can be also written by

$$R_i^e=-\frac{\mathrm{cov}(m,R_i^e)}{E(m)^2}m+\varepsilon_i=\beta_i m+\varepsilon_i \tag{3}$$

which is called factor model where m is the risk factor, β_i is the beta and $E(m\varepsilon_i)=0$.

If we know the m and regress R_i^e on m by

$$R_i^e=\widehat{\beta}_i m+\widehat{\varepsilon}_i \tag{4}$$

It is easily shown that

$$E(\widehat{\beta}_i)=E(m'm)^{-1}E(m'R_i^e)=\beta \tag{5}$$

The estimated betas converge to true betas and are not biased.

However, in most cases we have no idea of SDF and only refer to some linear portfolio $\theta' R^e$ as mimicking of m.

Therefore

$$E(\theta' R^e R_i^e)=0 \tag{6}$$

$$R_i^e=-\frac{\mathrm{cov}(\theta' R^e,R_i^e)}{E(\theta' R^e)^2}\theta' R^e+\varepsilon_i=\beta_i\theta' R^e+\varepsilon_i \tag{7}$$

One general approach to choose $\theta' R^e$ is to regress R_i^e on $\theta' R^e$:

$$R_i^e=\widehat{\alpha}_i+\widehat{\beta}_i\theta' R^e+\widehat{\varepsilon}_i \tag{8}$$

and compare the traditional statistical tests, such as t tests, likelihood ratio tests and GRS alpha test. The linear portfolio resulting in significant t value, large likelihood value and non-significant alpha is considered to be a good choice of mimicking m.

A. Estimation Bias of Beta

Let $X=\theta' R^e, Y=R_i^e$

$$\begin{aligned}E(\widehat{\beta}_i)&=E(X'X)^{-1}E(X'Y)\\&=E(X'X)^{-1}E(X'(\beta_i X+\varepsilon_i))\\&=\beta_i+E(X'X)^{-1}E(X'\varepsilon_i)\end{aligned} \tag{9}$$

if the weight of R_i^e in mimicking portfolio $\theta_i\neq 0$,

$$E(X'X)^{-1}E(X'\varepsilon_i)=\theta_i E(X'X)^{-1}\sigma_i^2\neq 0 \tag{10}$$

The estimated beta is biased from the true beta,

$$E(\widehat{\beta}_i)\neq\beta_i \tag{11}$$

Next we will consider some special cases to show the possible problems brought by the estimation bias.

Case 1. $\beta_i=0$. The returns follow random walk. However,

$$E(\widehat{\beta}_i)=E(X'X)^{-1}E(X'\varepsilon_i)=\theta_i E(X'X)^{-1}\sigma_i^2\neq 0 \tag{12}$$

In this case, the estimation is totally misleading for making conclusion about the risk-return tradeoff.

Case 2. $\beta\neq 0$, $\theta'\beta=0$. The asset return is related to the

mmeybodi@aut.ac.ir

risk, however the mimicking factor includes no useful information about the true factor.

In this case,

$$E(\widehat{\beta}_i) \neq 0 \tag{13}$$

The estimation is also totally misleading for making conclusion about risk-return tradeoff. This depends on the choice of θ.

Case 3. $\beta \neq 0$, $\theta'\beta \neq 0$. The estimated beta captures both useful risk information and useless noise information. As a result, it is biased.

Therefore, when testing asset pricing models in time series, the result of significant nonzero beta should not be directly considered as the evidence of useful risk information. Case 1, 2, 3 all have nonzero estimated betas. However, they are quite different in capturing the risk information.

B. Estimation bias of Intercept

Then we will show that the estimation of intercept is also biased.

It can be easily shown that

$$E(\widehat{\alpha}_i) = E(Y) - E(\widehat{\beta}_i)E(X) \neq E(Y) - \beta_i E(X) \neq 0 \tag{14}$$

Case 1. $E(X) = 0, E(\widehat{\alpha}_i) = \alpha_i = 0$ .The estimation of intercept is unbiased.

Case 2. $E(X) \neq 0, E(\widehat{\alpha}_i) \neq 0$. (15)

Therefore, when we regress excess return on the mimicking portfolio, the results are biased. It is no sense or pointless to depend on the statistical tests of such biased results to find out the suitable mimicking portfolio of SDF. Under the condition of estimation bias, a linear portfolio with significant alpha and small likelihood value is possible to be the true mimicking portfolio, while another portfolio with non-significant alpha and large likelihood value tend to be a bad model to represent the risk information in SDF. The traditional statistical tests, in this way, are not robust to test the asset pricing models with estimation bias.

III. Simulation

In order to show the estimation biases in testing asset pricing theories, we simulate the returns by different data generating process (DGP), regress the simulated returns on mimicking risk factor and do the traditional statistical tests.

A. One factor model

The Data Generating Process (DGP) of return r_{it} is written by

$$r_{it} = r_{ft} + \beta_i(x_t - r_{ft}) + \varepsilon_{it} \tag{16}$$

Where $\varepsilon_{it} \sim i.i.d.(0, \sigma_i^2)$, $i = 1,2,...,N$, $t = 1,2,...,T$, r_{it} is the return of portfolio i at time t, r_{ft} is the risk free interest rate at time t, x_t is the risk factor, β_i is the simulated beta for portfolio i.

In simulation, the risk factor x_t is assumed to follow AR (1) process by:

$$x_t = 0.01 + 0.5x_{t-1} + v_t, v_t \sim i.i.d.N(0, 25\%) \tag{17}$$

To make the estimation bias more intuitively, we let $\beta_i = 1$, $\sigma_i = 30\%$, $i = 1,...,N$. The size follows uniform distribution between (1000, 10000), N=25, $r_{ft} = 6\%$. In regression, x_t is replaced by the size weighted portfolio $r_{mt} = \sum_{i=1}^{N} \theta_i r_{it}$, where θ_i is the size weight of portfolio i in the market, $\sum_{i=1}^{N} \theta_i = 1$. We do 100 simulations and compute the average of statistical rates.

Table I shows the empirical improvement of introducing r_{mt} in regression by traditional statistical tests, including t tests, GRS tests and likelihood tests. Both t tests and likelihood tests imply that one factor model makes significant improvement on explaining the changes of portfolio return than without it (random walk model). However, the GRS test suggests that although one factor improves the sample fit degree, the intercepts are significant different from zero. If we depend on such evidence, we will reject one factor model and consider multi factor model to be a right model specification. As a result, these evidences are possible to be misleading for finding true asset pricing models.

B. Random walk model

The DGP of return r_{it} is written by random walk model:

$$r_{it} = r_{ft} + \varepsilon_{it}, \varepsilon_{it} \sim i.i.d.(0, \sigma_i^2), i = 1,2,...,N, t = 1,2,...,T \tag{18}$$

The other parameters keep unchanged, i.e., $r_{ft} = 6\%$, $\sigma_i = 30\%$, $i = 1,2,...,N$, N=25. In regression, x_t is replaced by the size weighted portfolio $r_{mt} = \sum_{i=1}^{N} \theta_i r_{it}$, where θ_i is the size weight of portfolio i at the market, $\sum_{i=1}^{N} \theta_i = 1$. We do 100 simulations and compute the average of statistical rates.

Table II shows the empirical improvement of considering r_{mt} in regression by traditional statistical tests, including t tests, GRS tests and likelihood tests. Although the true model is random walk model, t tests and likelihood tests suggest that one factor model is significant. GRS test shows that the

TABLE I Traditional Test When Returns Follow One Factor Model[a]

Model: $r_{it} = r_{ft} + \beta_i(x_t - r_{ft}) + \varepsilon_{it}$, $i = 1,2,...,N$		
Significance Rates of β_i :T Test		
	5% Level	1% Level
T=400	100%	100%
T=600	100%	100%
T=1000	100%	100%
Significance Rates of α_i :GRS Test		
T=400	78.22%	76.24%
T=600	75.25%	70.30%
T=1000	91.09%	89.11%
Significance Rates of One Factor Model: Likelihood Test		
T=400	100%	100%
T=600	100%	100%
T=1000	100%	100%

[a] We did 100 simulations to compute the average significant rates.

mmeybodi@aut.ac.ir

TABLE II TRADITIONAL TEST WHEN RETURNS FOLLOW RANDOM WALK MODEL[a]

Model: $r_{it} = r_{ft} + \varepsilon_{it}$, $i = 1,2,...,N$		
Significance Rates of β_i :T Test		
	5% Level	1% Level
T=400	77.96%	72.28%
T=600	83.60%	76.68%
T=1000	88.92%	85.68%
Significance Rates of α_i :GRS Test		
T=400	76.24%	71.29%
T=600	75.25%	70.30%
T=1000	82.18%	79.21%
Significance Rates of One Factor Model: Likelihood Test		
T=400	77.84%	68.92%
T=600	83.60%	74.84%
T=1000	88.92%	83.72%

[a] We did 100 simulations to compute the average significant rates.

intercepts are significant different from zero. Depending on these evidences, we will conclude that one factor model performs better than random walk model. However, it is not enough to explain the "abnormalities" by one factor model. As a result, we will introduce other risk factors. It is quite misleading to find the true risk-return tradeoff based on such evidence.

Therefore, because of the estimation biases in testing asset pricing models, the traditional statistical tests fail to find out the right model specification. The main reason is that they have no power to check whether the significant results come from useful information or noise information. As a result, the parameters are always significant whether the factor we want to introduce into model includes some useful risk information or not.

IV. CONCLUSION

We discuss the estimation biases problem of testing asset pricing models in time series when linear portfolios are used as mimicking risk factors. Since such risk factors themselves include noise information, the traditional statistical tests have no power to check whether the significant results come from correlation between useful risk information or from useless noise information. As a result, theses tests are not robust for testing asset pricing models.

Simulation shows that whether the stock return follows random walk model or one factor model, when we use the linear portfolio as mimicking risk factor, the estimation are both significant in traditional statistical test. As a result, it will be misleading if we just use these evidences to compare asset pricing models.

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mmeybodi@aut.ac.ir

Impact of Short Sale Constraints on Pricing of Restricted Stocks*

Hai Lin
Department of Finance and Wangyanan Institute for Studies in Economics, Xiamen University, Xiamen, 361005, China.
Zhenlong Zheng
Department of Finance, Xiamen University, Xiamen, 361005, China.

Abstract: This paper introduces the short sale constraints into the consumption-portfolio choice of the investor and studies the pricing of restricted stocks under the short sale constraints. The results show that the short sale constraints have a significant impact on the value of restricted stocks.

I. INTRODUCTION

Recently, more and more attention is focused on the allocation of assets more generally, including both the liquid assets and illiquid assets, such as human capital, real estate and some illiquid assets due to the law regulations. In reality, many stocks are subject to some kinds of resale restrictions in the financial markets. One example is the restricted stocks issued in USA, which are issued by a company but not registered with the Securities and Exchange Commission (SEC) and can be sold via private placement to sophisticated investors but cannot resold in the open market for one-year holding period, and limited amounts can be sold after that. More broadly, sale restrictions are usually included in executive stock or stock-option based compensation contracts. Ref. [1] found that the average waiting period before the options can be exercised was 23.6 months. Similar lockups are also usually part of the contract between the issuer and the underwriter in the vast majority of IPOs. Most lockups do not allow the company insiders (officers, directors, employers, their friends and family, and venture capitalists) to sell their shares for a period of 180 days. Ref. [2] reported that Morgan Stanley agreed to a two year lockup period in its IPO. The holders of these restricted stocks, therefore, bear some costs of holding an illiquid portfolio for some periods.

Another important case is in China where most listed companies have two classes of shares: Restricted Institutional Shares (RIS) which are almost completely illiquid and common shares that are traded on stock exchanges. Most of the RIS are held by the state with a purpose to control the economy.

RIS have to be transacted through private placement. Starting in 2000, the Chinese government has allowed for auctions of these shares. Now, in order to further push the market reform, the government is considering giving up the resale restriction and makes the RIS publicly traded so that she could sell them and quit some competitive areas. Since it will change the value of the restricted stocks immediately and deliver a large impact on the market, how to price the restricted shares with correspondence to the common shares remains a key problem with a lot of concerns.

Ref. [3] did a pioneer work on the impact of illiquidity on the portfolio choice in a framework of two assets (one is risk free, the other is risky but illiquid for some period). The liquidity constraint influenced the portfolios of the investors significantly, and resulted in the decrease of the risky assets.

Ref. [4] then studied the impact of illiquidity on the asset allocation by considering a three assets model (one is risk free asset, one is liquid market portfolio, another is the illiquid asset). It also demonstrated that the illiquidity made a big impact on the asset value.

Ref. [5] studied the general equilibrium pricing for the two assets (one is liquid, the other is illiquid) with two heterogeneous investors. The pricing results showed that even if the dividends of the two assets are the same, the price of liquid asset could be 25% higher than that of illiquid asset.

Ref. [6], Ref. [7], Ref. [8] and Ref. [9] also did some relevant work. Ref. [10] studied the consumption and asset pricing under the short sale constraints.

The above literature applied the continuous time framework. In discrete time, Ref. [11], Ref. [12] did some researches on the best consumption behavior under uncertainty.

However, there has been much less attention paid to understand the direct links between the short sale constraints and the discounts of restricted stocks. In China, in order to push the construction of short selling mechanism, the exchanges have forwarded some policies. However, there are still strict regulations on short selling in China. For example, the margin rate for short selling is at least 50%, and the short period could not exceed six months, etc. In USA, although short sale is permitted in general, two major additional transaction costs would arise: (i) the short seller should pay fee, which is embedded in the level of "rebate rate". This rebate rate is the interest rate that investors earn on their

* Earlier version of this paper was presented at Cornell University with the title "Impact of short sale constraints on the pricing of illiquid assets". We are especially grateful to the discussions with F. Longstaff in UCLA. Thanks for the kindly suggestions from M. Lewis and other seminar participants at Cornell University. Contact Information: Hai Lin, Department of Finance, Xiamen University, Xiamen, 361005, China. Phone (Fax): 0086-592-2186976. Email: cfc@xmu.edu.cn.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 175–178.
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mmeybodi@aut.ac.ir

required cash deposit to the proceeds of short sale. (ii) The stocks can be recalled at any time. The existence of short sale constraint thus make the investors reluctant to hold the restricted stocks with respect to otherwise similar common stocks, which results in the discounts of restricted stocks.

This research thus introduces the short sale constraints by following the model of Ref. [4], and tries to study the impact of illiquidity on asset pricing under the short sale constraints. Compared with Ref. [4], our differences are: Ref. [4] assumes the short sales are permitted, while we would like to assume different market conditions to make it more general; Secondly, Ref. [4] applies the continuous time framework, while we would like to use discrete MDP stochastic dynamic programming theories. One reason for the preference of discrete time is that we could add the constraints more easily to the action sets to consider different market conditions. Thirdly, the impact of illiquidity under the condition short sales are permitted will be much less than if short sales are constrained, this research can also contributes to study the impact of short sales constraints on asset allocations and pricing.

II. Model

In this section, we model the consumption-portfolio choice of a representative investor where some portion of his wealth is in restricted stocks that he cannot sell for a given period of time. We describe the model in details.

(1) There is a representative investor with initial wealth W (liquid wealth W_1, illiquid wealth W_2) and log utility:

$$U(C)=\ln(C) \tag{1}$$

(2) There are three assets. one is risk-free asset B_t with constant return r:

$$B_{t+\Delta t}=B_t\exp(r\Delta t) \tag{2}$$

one is market portfolio M_t with price dynamics following

$$M_{t+\Delta}=M_t\exp\left(\left(r+\mu-\frac{\sigma^2}{2}\right)\Delta t+\sigma\sqrt{\Delta t}\varepsilon_1\right) \tag{3}$$

where μ is the risk premium, σ is the volatility, ε_1 is the standard normal distribution random variable. Then the continuous return $y_{1t}(\Delta t)$ follows the following dynamics

$$y_{1t}(\Delta t)=\left(r+\mu-\frac{\sigma^2}{2}\right)\Delta t+\sigma\sqrt{\Delta t}\varepsilon_1 \tag{4}$$

another is the stock that investor holds with resale restriction with dynamics

$$S_{t+\Delta}=S_t\exp\left(\left(r+\lambda-\frac{v^2}{2}\right)\Delta t+v\sqrt{\Delta t}\varepsilon_2\right) \tag{5}$$

where λ, v are the risk premium and the volatility. By CAPM,

$$\lambda=\rho v/\sigma \tag{6}$$

where ρ is the correlation between ε_1 and ε_2.

Similarly, the continuous return $y_{2t}(\Delta t)$ is

$$y_{2t}(\Delta t)=\left(r+\lambda-\frac{v^2}{2}\right)\Delta t+v\sqrt{\Delta t}\varepsilon_2 \tag{7}$$

(3) The investor is to maximize the expected utility in a finite horizon T by choose the consumption C, the investment in the market portfolio X (investment in risk-free asset is then W_1-C-X):

$$V(W_1,W_2)=\max_{C,X}E\left(\sum_{t=0}^{T-1}e^{-\beta t}\ln(C_t)+e^{-\beta T}\ln(W_T)\right) \tag{8}$$

where β is the time discount factor.

III. Markov Decision Process (MDP)

It is clear that the objective in the economic model could be stated as the discounted reward maximization under a finite horizon. We could then formulate the model as a Markov Decision Process.

(1) Decision Epoch:

$$t=\{0,\Delta t,...,n\Delta t\} \tag{9}$$

where $n\Delta t=T-\Delta t$.

(2) State:

$$S_t=(W_{1t},W_{2t}) \tag{10}$$

with dynamics

$$W_{1t+1}=X_t\exp(y_{1t}(\Delta t))+(W_{1t}-C_t-X_t)\exp(r\Delta t) \tag{11}$$

$$W_{2t+1}=W_{2t}\exp(y_{2t}(\Delta t)) \tag{12}$$

(3) Action:

$$A_t=(C_t,X_t) \tag{13}$$

Case 1: if short sale is permitted then

$$C_t\in(0,\infty),X_t\in(-\infty,\infty) \tag{14}$$

Case 2: if the market portfolio could not be short sold. Then

$$C_t\in(0,\infty),X_t\in[0,\infty) \tag{15}$$

Case 3: if both risk-free asset and market portfolio could not be short sold, then

$$C_t\in(0,\infty),X_t\in[0,\infty),C_t+X_t\le W_{1t} \tag{16}$$

(4) Reward function:

$$r(s_t,a_t)=\ln(C_t),r_T(s_T)=\ln(W_{1T}+W_{2T}) \tag{17}$$

(5) Transition Probability Matrix:

$$\begin{aligned}&f\left((W_{1t+\Delta t},W_{2t+\Delta t})=(x,y)\,|\,(W_{1t},W_{2t}),(C_t,X_t)\right)\\&=f\left(\varepsilon_1=\frac{\ln\left(\frac{x-A_t}{X_t}\right)-B_t}{\sigma\sqrt{\Delta t}},\varepsilon_2=\frac{\ln(y/W_{2t})-C_t}{v\sqrt{\Delta t}}\right)\end{aligned} \tag{18}$$

where $f(\varepsilon_1=z_1,\varepsilon_2=z_2)$ is the density function of bivariate normal distribution with correlation ρ.

$$A_t=(W_{1t}-C_t-X_t)\exp(r\Delta t) \tag{19}$$

$$B_t=\left(r+\mu-\tfrac{\sigma^2}{2}\right)\Delta t \tag{20}$$

$$C_t=\left(r+\lambda-\tfrac{v^2}{2}\right)\Delta t \tag{21}$$

When $W_2=0$, the above model return to the case with liquid assets, and similar MDP model can be built.

mmeybodi@aut.ac.ir

IV. Algorithm And Simulation

We may use the backward induction algorithm to do with the above MDP problem. In order to simulate the dynamics of asset price, we follow binominal method proposed by Ref. [5], i.e.,

$$M_{t+\Delta t} = M_t \exp\left(\left(r+\mu-\frac{\sigma^2}{2}\right)\Delta t \pm \sigma\sqrt{\Delta t}\right) \tag{22}$$

$$S_{t+\Delta t} = S_t \exp\left((r+\lambda-\frac{v^2}{2})\Delta t \pm v\sqrt{\Delta t}\right) \tag{23}$$

and

$$P\left(M_{t+\Delta t}=M_t\exp\left(D\Delta t+\sigma\sqrt{\Delta t}\right),S_{t+\Delta t}=S_t\exp\left(E\Delta t+v\sqrt{\Delta t}\right)\right)$$
$$=P\left(M_{t+\Delta t}=M_t\exp\left(D\Delta t-\sigma\sqrt{\Delta t}\right),S_{t+\Delta t}=S_t\exp\left(E\Delta t-v\sqrt{\Delta t}\right)\right)$$
$$=(1+\rho)/4 \tag{24}$$

$$P\left(M_{t+\Delta t}=M_t\exp\left(D\Delta t+\sigma\sqrt{\Delta t}\right),S_{t+\Delta t}=S_t\exp\left(E\Delta t-v\sqrt{\Delta t}\right)\right)$$
$$=P\left(M_{t+\Delta t}=M_t\exp\left(D\Delta t-\sigma\sqrt{\Delta t}\right),S_{t+\Delta t}=S_t\exp\left(E\Delta t+v\sqrt{\Delta t}\right)\right)$$
$$=(1-\rho)/4 \tag{25}$$

where $D=r+\mu-\frac{\sigma^2}{2}$, $E=r+\lambda-\frac{v^2}{2}$. Thus it can ensure the correlation of two dynamics to be ρ.

The parameters are: $W=1$, $r=5\%$, $\mu=8\%$, $\sigma=25\%$, $v=30\%$, $\rho=0.9$, $T=3$. We let $W_2=0,0.3,0.5,0.7$ and the restricted term $\tau=1,2,3$, $\Delta t=1$.

Table I lists the results of the consumption, investment in the market portfolio and the value function for different cases. If short sale is permitted, the expected utility the investor could achieve is -4.61 if there is no restricted asset. The expected utility decreases with the increase of restricted wealth level and the restricted term. The results of consumption and investment in market portfolios are quite similar. The short sale constraints also have a significant impact on the consumption-portfolio choice and the expected utility of the investor. Such impact becomes more and more significant with the increase of restricted wealth level and the restricted term. For example, when $W_2=0.7,\tau=3$, the expected utility is only -6.37. This is about 40% lower than the expected utility with no illiquid wealth.

Therefore, it is obvious that the expected utility with no restricted stocks is higher than that with restricted stocks. In order to study the price discount of restricted stocks with respect to the liquid stocks, we first compute the wealth level W' to make the investor indifferent between the two conditions:

$$V(W')=V(W_1,W_2) \tag{26}$$

Obviously,

$$W'<W_1+W_2=1 \tag{27}$$

then we may compute the discount ratio of restricted stocks by

$$W'=W_1+(1-d)W_2 \tag{28}$$

TABLE I. Impact Of Illiquidity On Portfolio Choice[a]

	Illiquid Wealth (W_2)			
	(a) Short sale is permitted			
τ	0	0.3	0.5	0.7
1	0.27,0.96,-4.61	0.27,0.63,-4.61	0.27,0.41,-4.62	0.27,0.20,-4.63
2		0.27,0.63,-4.62	0.27,0.41,-4.63	0.26,0.20,-4.66
3		0.27,0.63,-4.63	0.25,0.36,-4.68	0.15,0.19,-5.08
	(b) Short sale of market portfolio is not permitted			
1	0.27,0.96,-4.61	0.27,0.63,-4.61	0.27,0.41,-4.62	0.27,0.20,-4.63
2		0.27,0.63,-4.62	0.27,0.41,-4.63	0.26,0.14,-4.66
3		0.27,0.63,-4.63	0.25,0.36,-4.69	0.15,0.12,-5.13
	(c) Short sale is not permitted			
1	0.27,0.96,-4.61	0.27,0.43,-4.62	0.27,0.23,-4.63	0.27,0.03,-4.64
2		0.27,0.43,-4.63	0.26,0.25,-4.65	0.15,0.15,-5.05
3		0.25,0.46,-4.68	0.18,0.33,-5.20	0.11,0.20,-6.37

[a] The values are the C, X and V, i.e., the consumption, investment in market portfolio and expected utility level.

$$d=1-\frac{W'-W_1}{W_2} \tag{29}$$

The discount results are shown in table II. The discount ratios increase with the restricted wealth level and the restricted term. They are also influenced significantly by short sale constraints. If short sale is permitted, most of the discount ratios are small. However, if short sale is not permitted, the discount ratio increases significantly. Specifically, when $W_2=0.7,\tau=3,$ the discount ratio is as high as 54.84%. This means if the restricted asset holds 70% of the investor wealth with a 3 year restricted term, his value is only one half of the liquid assets under the same condition.

V. Conclusion

This paper applies the stochastic dynamic programming theory of Markov Decision Process, introduces the short sale constraints into the consumption-portfolio choice of the investor and studies the pricing of restricted stocks under the short sale constraints. The results show that the short sale constraint has a significant impact on the value of illiquid assets. The discount ratios of restricted stocks are higher with short sale constraints than without short sale constraints.

The analysis of restricted stocks in this paper could be applied to price the Restricted Institutional Stocks in China. In China, short sale is still under strict regulation. Moreover, most of the parameters used in the simulations are consistent with the market. Therefore, the results could be regarded as a basic theoretical benchmark to determine the price of restricted institutional stocks. To price the individual RIS more exactly by the empirical data, is then for future research.

TABLE II. Impact Of Illiquidity On Asset Pricing[a]

τ / W_2	Short sale is permitted (%)			Short sale of market portfolio is not permitted (%)			(c) Short sale is not permitted (%)		
	0.3	0.5	0.7	0.3	0.5	0.7	0.3	0.5	0.7
1	0.47	0.66	0.84	0.47	0.66	0.80	0.27	0.48	0.69
2	1.00	1.50	2.07	1.00	1.50	2.17	0.63	1.60	15.70
3	2.07	3.90	17.60	2.07	4.54	18.76	5.50	25.06	50.84

[a] The value is the discount of restricted stock value under different conditions.

mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Blogfolios for Student-Centered Reflection and Communication

Harrison Hao Yang
State University of New York at Oswego
Oswego, NY 13126 USA
hyang2@oswego.edu

Abstract - **This paper presents: (1) the main issues and trends of portfolio development; (2) conceptual frameworks of using the weblog-based portfolio (blogfolio) as a means for enhancing performance-based teaching and learning; and (3) a case study which integrates the blogfolio into an online course for the purposes of building a sense of community and promoting student-centered collaboration, assessment, and reflection.**

I. Introduction

Developing a performance-based portfolio has increasingly become popular in the field of education due to its numerous benefits: fostering self-assessment and reflection, providing personal satisfaction and renewal, providing tools for empowerment, promoting collaboration, and providing a holistic approach to assessment [1]. Although the benefits of portfolios are very promising, developing a portfolio is quite challenging in practice: it takes several stages to process – collection, selection, reflection, projection/direction, and presentation [2]; it is time-consuming for students to assemble and for teachers to guide and provide feedback; unfocused instruction and/or ill-defined tasks lead to low reliability for evaluations in portfolio assessment; and the electronic portfolio requires a level of technological skill that not all teachers and students possess [3]. This paper reviews trends and issues connected with the portfolio development as gleaned from the literature. It then introduces the advantages and potentials of weblogs for developing educational portfolios. It also provides a case study which integrates the weblog as a mean for progress-oriented learning portfolio into an online course.

II. Trends And Issues Of Portfolios

The traditional portfolio is defined as a portable case for carrying loose papers or prints. *Port* means to carry and *folio* relates to pages or sheets of paper [4]. For some time, pre-service and in-service teachers have attempted to accompany this definition of portfolio. Their portfolios were developed as paper-based folders. However, the approach of traditional paper-based portfolios has been challenged to capture the dynamic and complex process of teaching and learning [5]. Related studies indicated that the traditional paper-based portfolio approach might increase the danger of paying too much attention on the final product rather than the process [6]; difficulty in upgrading [3]; substantial photocopying and reproduction costs [3][7]; and storage and retrieval problems [3][5]. As a result, more recent studies have reported the uses of electronic portfolios also known as e-portfolios or digital portfolios in teacher education.

An electronic portfolio is defined as a portfolio that uses electronic technologies, allowing the portfolio developer to collect and organize portfolio evidence/artifacts in many media types (audio, video, graphics, text)[8]. One commonly applied type of e-portfolios is the web-based portfolio, which is specifically created for and placed on the Web [9]. Web-based portfolios have some unique advantages, such as: providing a means of storing multiple iterations over time and a mechanism for ease of editing and revisions; providing instant access to various audiences from anywhere at any time; providing structured presentation which a viewer can choose contents from one section to another based on his or her need or preference; etc. A variety of studies indicated that the flexibility and convenience of web-based portfolio supported pre-service and in-service teachers to reorganize, reevaluate, reflect, and result in new insights [6][9][10][11][12][13]. In spite of significant benefits, there are some drawbacks of existing web-based portfolios. On one hand, typical web-based portfolios still require users to have the skills and knowledge of tools such as web editing software and FTP clients, which can be daunting to teachers; on the other hand, typical web-based portfolios can be read only by viewers and do not have the capability to allow viewers to leave their feedback, therefore, they are limited for easy and instant collaboration. Furthermore, while electronic portfolios are expanding in teacher education programs, and the participants are mounting, the question "electronic portfolios for whom?" has been raised. As one researcher argued, "the knowledge promoted under the guise of electronic portfolios is hardly student-centered. Very little research exists integrating student voices into the dialogue of electronic portfolios. The voices that are integrated are primarily those of administrators and some faculty" [14]. The literature suggests that reforming a new type of web-based portfolio, which simplifies the technology part of publishing content yet allows developers and peers to share resources and ideas for reflection and collaboration, is essential for teacher education.

III. Weblogs And Blogfolios

Weblogs are considered to be a means of significantly reducing the technical barriers to effective web publishing. Researchers have summarized some distinctive features of a weblog such as: automatic formatting of content in the form of

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 179–182.
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"headlines", followed by "entries", or "stories"; time- and date-stamp of entries; archiving of past entries; a search function to search through all entries; a "blogroll" - a list of other blogs read by the author(s) of the current blog; a section associated with each entry where readers can post comments on the entry; simple syndication of the site content via RSS (Really Simple Syndication); etc. [15] The reasons these features make weblogs very effective and attractive to users are two-fold: a weblog developer can edit or update a new entry without much knowledge of programming, formatting, and FTP; meanwhile, a weblog is constantly comprised of reflections and conversations from the developer and viewers, it stimulates interaction [15][16][17]. While one researcher noted, "weblogs, because of their flexibility, their public nature and their rich linking structure, can be a powerful tool in our pursuit of such a classroom. They allow us to visualize learning, contextualize course content, encourage meta-reflective practices, and practice collaboration" [18], two studies further confirmed and supported this statement. One study [19] examined weblogs as reflective conversational tools, and found weblogs supporting aspects of:

- Recording and representing one's personal patterns of meaning or actions;
- Reflecting upon the representations;
- Reiterating the process of explication and reflection;
- Shifting from a task-focused level to a learning-focused level of awareness;
- Supporting the construction of a personal mini-language to converse about the process of learning;
- Supporting a gradual internalization of the tool.

Another study [20] investigated weblogs on brain structure and function, and found that weblogs could:

- Promote critical and analytical thinking;
- Be a powerful promoter of creative, intuitive, and associational thinking;
- Promote analogical thinking;
- Be a powerful medium for increasing access and exposure to quality information;
- Combine the best of solitary reflection and social interaction.

Weblogs, therefore, have shown a great deal of potential impact on teacher education, and have supported students' self-reflection and self-evaluation of their learning. Particularly, it comes naturally that weblogs can be used for developing and reforming web-based portfolios in education. In his book [17], one educator described this new transformation in this way,

> The traditional portfolio process is supported almost perfectly by Weblogs. First, students collect the work they might want to consider highlighting in their portfolio and then they select those that represent their best work. They then reflect on the choices they made, something they can easily do in a blog post. Finally, they publish the result for others to see. Even more powerful is the idea that these portfolios could conceivably span many grades and many classes (p. 23).

To distinguish it from a typical web-based portfolio, a weblog-based portfolio is usually called a "blogfolio". Indeed, blogfolios have been adopted and implemented in education. At the institutional level, Office of Learning Technology at the University of British Columbia has developed and provided a blog/portfolio model for work flow, simplicity and user interaction. Each user of blogfolios could have his or her space with a stronger sense of ownership to reflect and post information and collaborate with one another [21]. At an individual level, teachers have been adopting blogfolio for their professional development and classroom teaching. For example, a math teacher at Wyoming Middle School in Wyoming, used blogfolios as repositories for the extended response that his students were completing in math class [22].

However, despite of huge potentials of weblogs for reflection, self-assessment, and communication, blogfolios are not as common as typical web-based portfolios in higher education institutions, specifically in their teacher education programs. Perhaps weblogs have broken down the technical barriers to effective web publishing significantly but have not changed many educators' minds. They doubt that weblogs can promote thoughtful and the measured responses. Their view is that "blogging honors the impulsive, the careless, the superficial – anything goes: what matters is that you get a place to say whatever you like in public" [18]. As one researcher pointed out, "one of the criticisms of blogs, and especially student blogs, is that the students write about nothing but trivia" [16]. Hence, it is crucial to conduct more authentic studies and to provide more concrete evidences on how the adoption and implementation of blogfolios can impact real-world teaching and learning in various ways. For instance, it is necessary to investigate the effectiveness of using a blogfolio as a vehicle for building a strong sense of community among students and supporting their online collaborative learning, communication, assessment, and reflection.

IV. Case Study: Blogfolios For Online Learning And Reflection

Teaching in online courses is an extremely complex and challenging function [23]. The question of how best to foster community on asynchronous online learning among learners as well as instructors, who are physically and timely separated from each other, has been raised [24][25]. Such separation may increase social insecurities, communication anxieties, and feelings of disconnectedness [26]; as a result, "the student becomes autonomous and isolated, procrastinates, and eventually drops out" [27]. Previous studies suggested that a sense of community, which was related to connectedness and learning, was essential for asynchronous text-based communication to occur [24][25]. To enhance a sense of community and promote student-centered collaboration, assessment, and reflection, we incorporated the blogfolio component in a text-based asynchronous distance course.

A. Participants and the Course

The participants of this study came from a section of students (n = 21) who were enrolled in the asynchronous online course entitled *Multimedia and Internet for Educators,* offered at a university in the northeastern region of the United States during the fall semester in 2006. Most of the participants were

mmeybodi@aut.ac.ir

part-time in-service teachers located in the same geographical area, who were pursuing graduate level education programs in content areas of literacy, biology, chemistry, earth science, mathematics, social studies, technology, etc.

The course provides an introduction and guide to current and emerging technology for pre- and in-service teachers. It is intended to help K-12 educators not only to use multimedia and Internet resources in their own education but also to integrate them into their work as teachers. In each module, participants are required not only to complete and submit the assignment, but also to collaborate on learning activities under a certain time frame: read each "Mini-Lecture" and supplemental materials; respond to the questions in each Mini-Lecture at the "Online Discussion" section; respond publicly to some or all of the questions submitted by classmates; reply to classmates who respond to the question. The assignments of this course include projects such as: using search engine and Web evaluation criteria to create their own webliography, in which selected and listed Internet resources can be used for the future references or projects [28]; building an inquiry-oriented WebQuest activity, in which "some or all of the information that learners interact with comes from resources on the internet, optionally supplemented with videoconferencing" [29]; etc.

B. Method

A structure with four consecutive segments incorporating both portfolio development and weblogging was designed and then implemented in the course. In the first segment, the concept and foundations for portfolio development were introduced; In the second segment, the features, components, applications, and resources of educational weblogs were presented; In the third segment, a guideline and requirements of developing a progress-oriented course blogfolio were provided. In the last segment, students' progress blogfolios were developed and accessible to their peers, where students engaged in continuous, thoughtful analysis of their learning on this course with reflection, evidence/assignments, and collaboration. By the final week of the semester, each student was required to complete a written report on his or her own learning experience and post it on his/her course blogfolio.

C. Data Collection and Instrumentation

To assess the effectiveness of progress-oriented course blogfolios on the sense of community for online collaborative learning and self-reflection, all 21 students from the course received Rovai's Classroom Community Scale (CCS) [30] survey at the end of the fall semester in 2006. The CCS, which was used to measure the sense of community for students of this study, included 20 items based on two factors: connectedness and learning. Among the returned surveys, 15 out of 21 students' responses (71%) were completed and usable. In addition, students' final reports posted on their blogfolios were collected and examined.

D. Results

It should be noted that the participants were selected by the way of convenience sampling because the researcher for this study was also the instructor of the course. The sample size was relatively small. Therefore, instead of any strict inferential attempts, the descriptive research design was utilized in this study.

Connectedness

Most of the participants indicated that the course blogfolio development made very positive impacts toward their cohesion, community spirit, trust, and interdependence from the course. On the connectedness subscale of the CCS, respondents overwhelmingly agreed and/or strongly agreed on items: "I feel that students in this course care about each other" (100%); "I feel connected to others in this course" (87%); "I trust others in this course" (100%); "I feel that I can reply on others in this course" (87%); and "I feel confident that others will support me" (100%). In addition, more than half of the respondents indicated that they agreed/strongly agreed on items: "I feel that this course is like a family" and "I feel that members of this course depend on me". On the other hand, respondents overwhelming disagreed/strongly disagreed on items: "I do not feel a spirit of community" (100%); "I feel isolated in this course" (93%); and "I feel uncertain about others in this course" (87%).

Self-reports from participants' course blogfolios also revealed that they perceived the course blogfolio was an incredible vehicle of reflection, self-assessment, and communication. Participants indicated that blogfolios provided opportunities for reviewing peers' works and revising their own projects, as was evident in the following one of participants' comments,

> One of the things I liked the most in this class was how fast I got responses from both the professor and my peers privately and publicly. I have to say that I am currently taking two online courses and by far this one was much more useful and more enjoyable. The readings were meaningful and not overwhelming. Sometimes I think that some teachers forget that we have lives outside of their courses. I do appreciate the fact that this course was manageable while learning a ton of information. I will be able to use everything that I have created for this course and I do plan to have fun with both the WebQuest and the blogfolio. I've never used a blog before so to be able to run a blog myself is quite impressive. I also think it's great that we are able to see projects of peers' work through their blogs. Once I was able to look through various projects from other students, I became much more comfortable and confident in the assignments.

Learning

Most of the participants indicated their positive and favorable feelings of community members regarding the degree to which they shared educational goals and experienced educational benefits by interacting with other members of the course. On the learning subscale of the CCS, respondents fully agreed/strongly agreed on items: "I feel that I am encouraged to ask questions" (100%); "I feel that I receive timely

mmeybodi@aut.ac.ir

feedback" (100%); and "I feel that I am given ample opportunities to learn" (100%). On the other hand, respondents overwhelmingly disagreed and/or strongly disagreed on items: "I feel that it is hard to get help when I have a question" (100%); "I feel uneasy exposing gaps in my understanding" (87%); "I feel reluctant to speak openly" (100%); "I feel that this course results in only modest learning" (93%); "I feel that other students do not help me learn" (100%); "I feel that my educational needs are not being met" (100%); and "I feel that this course does not promote a desire to learn" (100%).

Self-reports from participants' course blogfolios also revealed that they perceived favorably in sharing educational goals and had experienced educational benefits by interacting with other members, as was evident in the following two participants' comments:

> Before this course I must say I hadn't explored WebQuests in depth. I am so excited to have the WebQuests my classmates created. I feel that they will be a valuable resource in the future. Exploring their WebQuests really opened my eyes to the amount of possibilities which lie in using them in the classroom.
>
> I was also anxious to see my peer's final projects. I really liked that we could see each others' projects. I printed off some of my peers' work that I thought might be beneficial to an elementary classroom environment. The sharing of resources really helped me see others' amazing computer talents as well as organization skills. My weblog in this course gave me the opportunity to create, revise and reflect projects using the Web. Interacting with classmates through discussions within modules was enlightening and reaffirming.

V. Conclusion

Weblogs provide new channels through which news and information are disseminated outside the conventional mechanisms of traditional new media [31]. As one of the weblog applications in education, the blogfolio is still evolving. Although the effectiveness of the progress-oriented course blogfolio on student-centered collaboration, assessment, reflection, and their sense of community in an online course has been examined and confirmed in this paper's case study, the various potentials of blogfolios on student-centered teaching and learning are yet to be determined and fulfilled.

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mmeybodi@aut.ac.ir

Innovative Online Course Using an Integrated Virtual Reality Based E-Learning Tool with Course Management Tool

Hazim El-Mounayri*, Tamer Wasfy**, Eugenia Fernandez*, and Jeanne Peters**
*Purdue School of Eng. & Tech., IUPUI, Indianapolis, IN
**asciencetutor.com, Indianapolis, IN
helmouna@iupui.edu

ABSTRACT
An innovative online course in advanced manufacturing is developed based on a unique integration of a state-of-the-art learning tool (AVML, or Advanced Virtual Manufacturing Laboratory) with a course management tool (OnCourse). The AVML is a collaborative web-based virtual learning environment for integrated lecture and lab delivery that allows for the first time the delivery of effective, realistic and complete advanced manufacturing curriculum which includes hands-on practice. The system seamlessly and synergistically integrates multimedia lecture, interactive 3D simulation, and realistic experimentation in a virtual reality environment. The learning experience is further enhanced by the use of intelligent virtual tutors and lab instructors. The AVML is built around two engines. IVRESS™, which allows for the creation of virtual lab with near-realistic, fully functional, and interactive CNC machine tools. The development involves three main elements, namely, a simulator for CNC milling and lathe machines, a virtual-environment display engine, and an intelligent-agent engine. LEA™ (Learning Environment Agent), provides a platform for lecture delivery. The lecture is presented by the speaking virtual instructor and involves high end multimedia using flash and movies for real-life illustrations, 2D/3D interactive simulation, and different types of practice questions. The lecture material is delivered in different formats to address the needs of different types of learners (visual, auditory, and kinesthetic). On the other hand, OnCourse™ course management tool is seamlessly interfaced with the learning environment and acts as a gateway to the lectures and labs that are delivered in the AVML environment. It provides a platform for accessing/taking projects, homework, quizzes and exams, for online monitoring and assessment of student work and performance, and for supporting interaction and collaboration. In this paper, the implementation the course is presented. In addition, the results of the assessment of the usability of the interface of the learning environment is described and discussed.

I. INTRODUCTION

Online course delivery and development tools enable E-learning, which can be defined as course content or learning experiences delivered electronically over the Internet [1]. Such tools offer significant advantages by allowing 24-7 access to the educational material as well as self-paced learning. In addition, safety is guaranteed when practicing in a virtual lab, cost is lower when the training facility is in the cyberspace, and changes/upgrades are easier when dealing with electronic material / virtual classrooms/labs. The majority of electronic learning applications consist of html pages with embedded pictures, movies, and/or Macromedia Flash™ content.

A typical e-learning tool would/should support two aspects of learning activity, namely, instruction delivery and course management. The Advanced Learning Environment (ALE) [4] is a virtual learning portal for online education developed at the Florida Space Research Institute. ALE offers self-paced, web classes in a variety of general science and aerospace education topics. It supports synchronous web classes, collaboration tools, and community discussions, and includes a speech capability using pre-recorded speech. Another system, ANDES, is used by the University of Southern California (USC) for management and delivery of web courses and has a special authoring language, called ATML, to generate Web-based courseware [5]. Some of the common characteristics of most web-based course delivery systems are that courses are linear and the content is not readily reusable. In addition, they focus on one of the two aspects of e-learning (namely, delivery and management). More importantly, they do not provide an integrated environment for a complete course delivery that includes both lecture and lab components.

In order to facilitate authoring, maintaining and reusing of course material, object-oriented models for course material representation have been developed. For example, Tsai *et al.* [6] developed an object-oriented course model where the original teaching material is divided into objects according to the instructional objectives defined by the teacher. Those objects were then organized in a tree structure forming a hierarchical knowledge-base. The Sharable Content Object Reference Model (SCORM) [7] defines a Sharable Content Object (SCO) as the smallest stand-alone and meaningful component of a course that is reusable, interoperable and modular. Although SCORM is not in itself a tool, it is an emerging standard that is being deployed to various degrees in some online course development tools. SCORM addresses the ability to reuse, locate, and provide for interoperability of learning content. Another feature of SCORM is separation of control and content reusable learning objects. The LMS (Learning Management System) in SCORM is responsible for controlling the delivery and organization of the content. The SCOs can be arranged in any desired meaningful order and

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reused in multiple courses. The SCORM standard focuses on content and metadata and its primary applications are geared towards single-learner, self-paced and self-directed training.

Most web-based course delivery systems are based on the student reading the course material and looking at static or animated illustrations. Some course delivery systems, like the ALE system, present the material using pre-recorded speech with Flash animations and movies. Pre-recorded speech makes the course very hard to maintain and update. In addition, synchronizing the speech with the Flash content using pre-recorded speech is very hard.

Most web-based courses do not include synchronized 3D animated illustrations or intelligent photo-realistic animated human instructors. In addition, most of the web-based course delivery systems lack the interactivity provided by an instructor, which includes the ability of the learner to ask random questions related to the course and the system providing an intelligent answer. In fact, the virtual instructor can help point important parts of the course using gestures. Also, he/she can make the learning experience closer to an actual classroom learning experience.

In this work, a web-based integrated learning for both instruction delivery and course management that overcomes the above limitations is presented. The system consists of three main components, namely, LEA, IVRESS, and OnCourse.

II. E-LEARNING SYSTEM

In this section, the three components forming the e-learning tool used to develop and deliver the integrated web-based course are described.

2.1 LEA (Learning Environment Agent)

LEA [9] is an intelligent-agent engine which includes facilities for speech recognition and synthesis, a rule-based expert system natural-language interface (NLI) for recognizing the user's natural-language commands [9, 10], a hierarchical process knowledge base engine [9], and an unstructured knowledge base engine. LEA is the engine behind the AVML web-based framework. It is encapsulated in an ActiveX control which can run in a web-page and can display various user defined, sizable and movable mini-web browsers sub-windows (that can display any web content such as HTML, Flash, etc.)

One of the capabilities of LEA is the unstructured knowledge base engine. The unstructured knowledge consists of "knowledge items" that can be arranged in any order to form a lecture. A knowledge item is a short HTML segment with embedded multimedia content and LEA-specific tags. A knowledge-base file is simply a collection of knowledge items separated by new-line characters. LEA allows multiple knowledge-base files to be loaded. A file is loaded using its URL. Thus the knowledge base can lie anywhere on the web. LEA includes a search capability in order to be able to answer the user's questions from the unstructured knowledge-base. The following lectures were developed using LEA: 1) *Introductory lecture on CNC milling* (See Figure 1); *Introductory lecture on the FADAL CNC machine* (See Figure 2).

LEA also includes a structured hierarchical process knowledge capability that allows training users step-by-step through operating procedures [11]. Each process consists of a set of steps as well as other sub-processes. Each process and step can have pre- and post- constraints. Pre-constraints have to be satisfied before the step/process can be started. Post-constraints have to be satisfied before the step/process is completed. The agent can disseminate process knowledge using one of the following training modes. The desired mode is triggered using a natural-language user's command interpreted using the LEA rule-based expert system. The training modes are: *1) Process Tutor; 2) Process Info; 3) Process Guide*; *4) Process Supervisor; 5) Process Certification*; *6) Intelligent Virtual Assistant*.

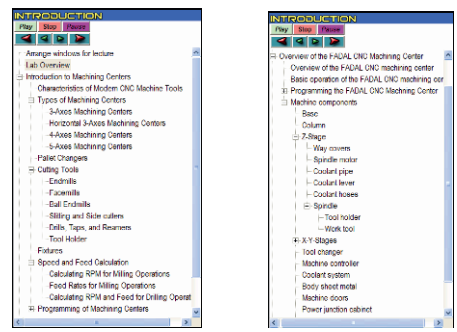


Fig. 1. Partial exploded view of the introductory lectures outlines: (Left) CNC milling; (Right) CNC machine components.

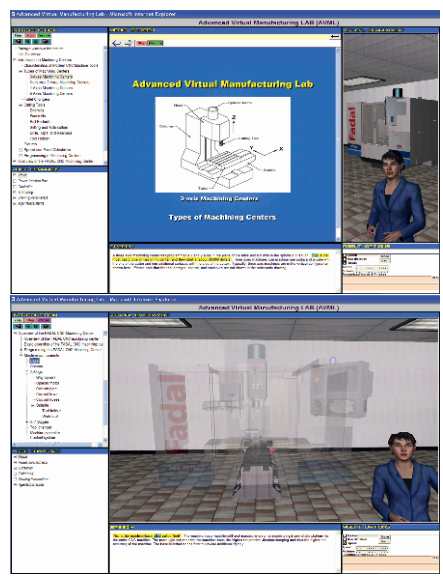


Fig. 2. Snapshots of the introductory lectures on CNC milling (top) and the CNC machine components (bottom).

mmeybodi@aut.ac.ir

The following CNC milling machine training processes were developed: *1) machine start-up; 2) machine shut-down, 3) load G-code from disk, and 4) running an existing G-code*. For example the machine-start up process consists of 6 steps: 1. Going to the milling machine power junction cabinet; 2. Switching on the red power lever (see Figure 3); 3. Pressing the green power button; 4. Going to the milling machine controller; 5. Pressing the green start button; 6. Pressing the keyboard manual button.

2.2 IVRESS (Integrated Virtual Reality Environment for Synthesis and Simulation)

IVRESS [8] is an object-oriented scene-graph based virtual-reality display engine. IVRESS has four classes of objects that can be used to construct VEs: 1) *Interface objects; 2) Geometric entities; 3) Finite elements; 4) Support objects*. All objects in IVRESS have the same basic structure. Each object has properties that determine its state and behavior, and methods, which are functions that it can perform. In addition, interface objects have events that are triggered when certain conditions, initiated by the user or the passage of time, are met. IVRESS includes two scripting languages VB-script and ECMA-script. Scripting allows setting the properties of the various objects, and writing custom event handling routines. IVRESS can interface with output devices, including immersive stereoscopic screen(s) and stereo speakers; and a variety of input devices, including body tracking (head and hands), haptic gloves, wand, joystick, mouse, microphone, and keyboard. IVRESS can read and write file formats for geometry data such as VRML 2.0, pictures such as Bitmaps, PNG, JPEG, and GIF; and movies such as MPEG and AVI. IVRESS objects perform the following functions:

- Display a textured photo-realistic animated model of the machine and lab (Figure 4).
- Boolean-based solid-modeling for geometric simulation of the cutting process through ACIS™ solid modeling kernel.
- Generate the machine sounds.
- Display animated photorealistic human avatars of virtual instructor(s) through the Haptek™ API.

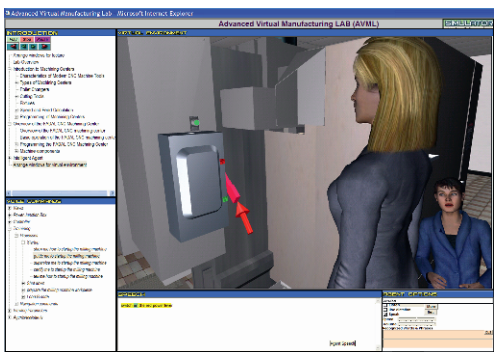


Fig. 3. A snapshot taken during training step 2 of the machine start-up procedure

2.3 OnCourse

Oncourse is an online course management system (CMS) that permits faculty and students to create, integrate, use, and maintain Web-based teaching and learning resources (Fig. 5) [12]. Oncourse offers content development and management tools through a single, consistent Web interface, and provides a framework for building teaching materials without requiring knowledge of programming or HTML [12]. Oncourse uses university databases to populate course templates that automatically create Web sites. Each course section appears as a unique Web site with an up-to-date class roster of all registered students [12]. User profiles, which are predefined individual Web sites that include their own tool set, are automatically created for everyone associated with the class [12]. Faculty and enrolled students access these integrated Web sites with their university usernames and passwords. Faculty and students edit their own information and add materials and resources, with privileges determined and authorized during login. Faculty activate courses, import settings and content from one semester to another, change default settings, and edit all aspects of course content [12].



Fig. 4. Virtual manufacturing lab

III. COURSE DEVELOPMENT

3.1 Lecture development

LEA™ (Learning Environment Agent) was used to develop a course on advanced manufacturing, which focuses on advanced machining using CNC (Computer Numerically Controlled) machine tools. Starting from traditional lecture material, LEA™'s modular unstructured knowledge-base was used to store the material in the form of HTML or XML "knowledge objects" with embedded multimedia content. Each knowledge object includes synchronized illustrations in the form of 2D and 3D animated multimedia flash illustrations and movies.

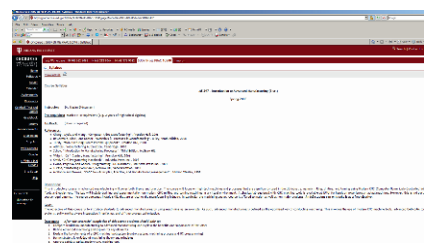


Fig. 5. Snapshot of user interface of OnCourse (on the left is the main menu; in the center is a course syllabus)

mmeybodi@aut.ac.ir

After developing the course, it is delivered on LEA™ by synthesizing the knowledge object text using a text-to-speech engine. The outcome of the speech synthesis (computer-to-learner communication) was found satisfactory. In fact, the lecture delivered by the virtual tutor was comprehensible throughout the whole course.

3.1.1 Lecture outline

A typical outline file (as typed by the course instructor) is shown in Figure 6. The outline consists of the subject headings with child headings indented using tabs. Each heading is "piped" into a question that is sent to the knowledge disseminator.

The instructor creates the course by writing the course outline as shown above. Figure 7 shows the corresponding outline displayed by LEA. The instructor writes the subject headings and the corresponding question, which will be sent to the knowledge disseminator. The question can be in the form of a natural-language question in which case the search engine will search the knowledge base for the "best" answer to that question. Alternatively, the question can search for a specific label in the knowledge-base and display all the knowledge objects, which have this label. This is done using the special tag "<!IVRalias label_name>". The search engine will only return the knowledge object(s) which has the label "label_name". Thus, the course consists of the answers to the outline questions.

```
1. Theory | what is <IVRalias AVNL1-theory>
        1.1 Introduction | what is <IVRalias AVNL1.1-intro>
                1.1.1 Conventional (manual) machines | what is <IVRalias AVNL1.1.1-conventional>
                        Disadvantages of manual machines | what is <IVRalias AVNL1.1.1-conventional_dis>
                1.1.2 Numerical Control (NC) | what is <IVRalias AVNL1.1.2-NC>
                        Features of NC machines  | what is <IVRalias AVNL1.1.2-features_NC>
                        Components of NC machines  | what is <IVRalias AVNL1.1.2-comp_NC>
                        Advantages of NC systems  what is <IVRalias AVNL1.1.2-advantages_NC>
                        Disadvantages of NC systems  what is <IVRalias AVNL1.1.2-disadvantages_NC>
                1.1.3 Computer Numerical Control (CNC)  what is <IVRalias AVNL1.1.3-CNC_define>
                        Special features of CNC machines 1-4  | what is <IVRalias AVNL1.1.3-CNC_features1-4>
                        Special features of CNC machines 5  | what is <IVRalias AVNL1.1.3-CNC_features5>
                        Special features of CNC machines 7-11  | what is <IVRalias AVNL1.1.3-CNC_features6-11>
                        Components of a CNC system | what is <IVRalias AVNL1.1.3-CNC_components>
                        Basic operation of a CNC system | what is <IVRalias AVNL1.1.3-CNC_operation>
                        Advantages of CNC machines 1-6  | what is <IVRalias AVNL1.1.3-CNC_advantages-1>
                        Advantages of CNC machines 7-11 | what is <IVRalias AVNL1.1.3-CNC_advantages-2>
                        Industrial applications of CNC  what is <IVRalias AVNL1.1.3-CNC_app>
                                Machining | what is <IVRalias AVNL1.1.3-CNC_app_machining>
                                Wire EDM | what is <IVRalias AVNL1.1.3-CNC_app_EDM>
                                Laser cutting  what is <IVRalias AVNL1.1.3-CNC_app_laser>
                                Fabrication and welding | what is <IVRalias AVNL1.1.3-CNC_app_fabrication>
                                Pressmork | what is <IVRalias AVNL1.1.3-CNC_app_press>
                                Inspection and measurement | what is <IVRalias AVNL1.1.3-CNC_app_inspection>
                                Assembly | what is <IVRalias AVNL1.1.3-CNC_app_assembly>
                                Materials handling | what is <IVRalias AVNL1.1.3-CNC_app_handling>
4. NC Programming  what is <IVRalias AVNL4-NC_programming>
        4.1 Basics | what is <IVRalias AVNL4.1-Basics>
                4.1.1 Coordinate Systems | what is <IVRalias AVNL4.1.1-CoordinateSystems>
                        4.1.1.1 Cartesian Coordinate System | what is <IVRalias AVNL4.1.1.1-CartesianCoordinateSystem>
                        4.1.1.2 ABC Axes | what is <IVRalias AVNL4.1.1.2-ABCAxes>
                        4.1.1.3 Quadrants | what is <IVRalias AVNL4.1.1.3-Quadrants>
                        4.1.1.4 Axes Conventions  what is <IVRalias AVNL4.1.1.4-AxesConventions>
                        4.1.1.5 Relative Motion | what is <IVRalias AVNL4.1.1.5-RelativeMotion>
                        4.1.1.6 Machine Conventions  what is <IVRalias AVNL4.1.1.6-MachineConventions>
                        4.1.1.7 Positioning Modes | what is <IVRalias AVNL4.1.1.7-PositioningModes>
                                4.1.1.7.1 Absolute Positioning | what is <IVRalias AVNL4.1.1.7.1-Absolute>
                                4.1.1.7.2 Incremental Positioning | what is <IVRalias AVNL4.1.1.7.2-Incremental>
                                4.1.1.7.3 Positioning Example | what is <IVRalias AVNL4.1.1.7.3-PositioningExample>
                4.1.2 Modal and Non-Modal Commands | what is <IVRalias AVNL4.1.2-ModalIntro>
                        4.1.2.1 Modal Commands | what is <IVRalias AVNL4.1.2.1-ModalCommands>
                        4.1.2.2 Non-Modal Commands | what is <IVRalias AVNL4.1.2.2-NonModalCommands>
                4.1.3 Setting Units | what is <IVRalias AVNL4.1.3-SettingUnits>
                4.1.4 Program Format  what is <IVRalias AVNL4.1.4-ProgramFormat>
                        4.1.4.1 Word Address Format  what is <IVRalias AVNL4.1.4.1-WordAddressFormat>
                                4.1.4.1.1 Word Order | what is <IVRalias AVNL4.1.4.1.1-WordOrder>
                                4.1.4.1.2 Conflicting Commands | what is <IVRalias AVNL4.1.4.1.2-ConflictingCommands>
                        4.1.4.2 Program Number | what is <IVRalias AVNL4.1.4.2-ProgramNumber>
                                4.1.4.2.1 Protected Programs | what is <IVRalias AVNL4.1.4.2.1-ProtectedPrograms>
                        4.1.4.3 Line Numbers | what is <IVRalias AVNL4.1.4.3-LineNumbers>
                        4.1.4.4 Program Documentation | what is <IVRalias AVNL4.1.4.4-ProgramDocumentation>
                        4.1.4.5 Program Name | what is <IVRalias AVNL4.1.4.5-ProgramName>
                4.1.5 Symbols | what is <IVRalias AVNL4.1.5-Symbols>
```

Fig. 6. Partial course outline (written in HTML)

Unstructured knowledge is natural-language knowledge that is in sources such as scientific papers, documents, web pages, etc. Unstructured knowledge in LEA consists of "knowledge objects" that can be arranged in any order to form a lecture. One knowledge object can be used in multiple courses. A knowledge object is a short HTML/XML segment with embedded multimedia content as well as LEA-specific tags for controlling the agent avatar and synchronize the multimedia content with the speech. A knowledge object can also be a simple ASCII text segment. A knowledge-base file is simply a collection of knowledge items separated by new-lines. LEA allows multiple knowledge-base files to be loaded. A file is loaded using its URL. Thus the knowledge base can be located anywhere on the web. LEA includes a text search capability to enable answering the user's questions from the unstructured knowledge-base.

The knowledge disseminator sends this knowledge object as is to the course presentation window, which is essentially a web browser. The LEA-specific tags are ignored by the browser because they are in the form of comment tags. The knowledge disseminator also strips all the tags from the knowledge object (thus all what is left is the text of the sentences) and then sends this text to the speech window and to the text-to-speech engine to be spoken. The text-to-speech engine provides the sentence events that are used to synchronize the animations of the graphical illustrations (in the course presentation window), the agent gestures, and the sentence highlighting. The text-to-speech engine also provides the word events that are used to highlight the words and the viseme events that are used for lip-synching of the virtual instructor.

3.2 Lab component

3.2.1 Virtual lab development

The manufacturing lab component of the course consists of fully functional virtual CNC machines which are developed using IVRESS™ commercial software. The resulting environment involves three main elements, namely, a simulator for a CNC milling machine and a CNC lathe, a virtual-environment display engine, and an intelligent-agent engine. The virtual environment provides training on different operating procedures. An intelligent virtual tutor, with the help of a virtual lab assistant, provides training in different modes. Operating procedures are enhanced with the use of movies showing real-life illustration. Figure 8 shows a fully functional CNC Vertical machining center that was modeled.

3.2.2 Outline of lab component

Figure 9 shows a partially exploded view of the outline of the virtual lab component of the course. Current training procedures include:

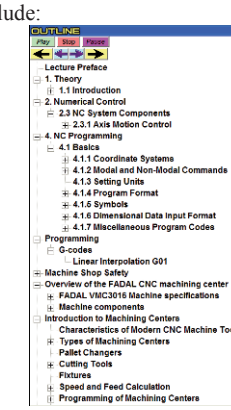


Fig. 7. Partial exploded view of the lecture outline as displayed on the interface

mmeybodi@aut.ac.ir

1) Start-up procedure; 2) Shut down procedure; 3) Workpiece preparation procedure; and 4) G-code loading and running procedure. For each one of these cases, the learner can choose one of five training modes: 1) "Show me"; 2) "Guide me"; 3) "Supervise me"; 4) "Certify me"; 5) "Tell me".

3.3 Interfacing the AVML with OnCourse

In addition to its management capabilities listed above, Oncourse is used here as the gateway to the lectures and labs that are delivered in the AVML environment, by providing a platform for accessing/taking projects, homework, quizzes and exams, and allowing online monitoring and assessment of student work and performance. The idea is to interface OnCourse (Figure 10.a) to the AVML (Figure 10.b). The two-layer online course will be accessed from and administered through OnCourse but taught using the AVML.

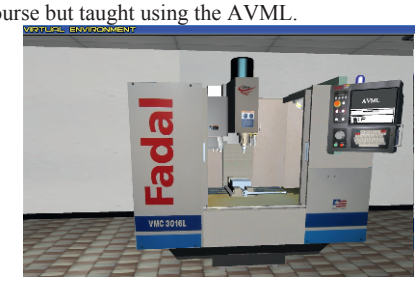


Fig. 8. Vertical CNC milling machine in the virtual environment

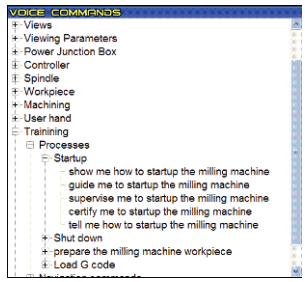


Fig. 9. A portion of the outline that is partially exploded

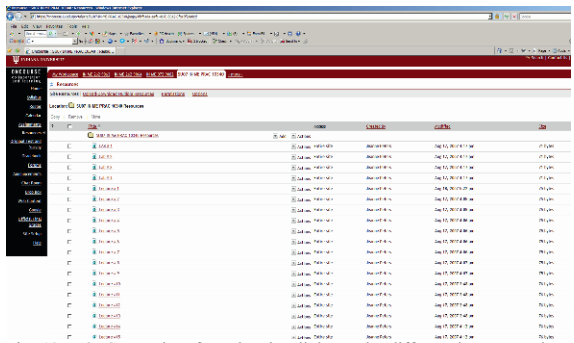


Fig. 10.a. OnCourse interface showing links to the different lectures and labs of the course (under the "Resources" heading). For example, if student clicks on Lab#3, then this would open the AVML and start delivering this lab (as shown below).

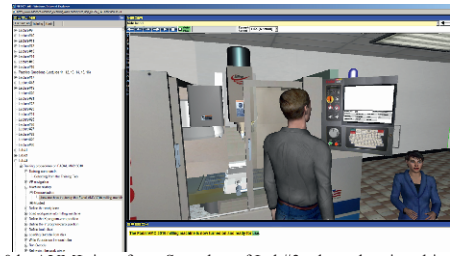


Fig. 10.b. AVML interface: Snapshot of Lab#3 where the virtual instructor is teaching the student how to start up the machine through a step-by-step procedure that is conducted by the virtual lab (or machine) agent. In the snapshot, we see the modern CNC machine tool (FADAL VMC 31016) that is near-realistic, interactive, and fully functional (with sounds, lighting, kinematics, dynamics, etc.)

The process for interfacing the instruction delivery tool (AVML or integrated LEA-IVRESS) with the instruction management tool (OnCourse) was made straightforward and very practical by the fact that the former is web-based and the latter supports functionality for web link –based interfacing. In fact, OnCourse has a feature called "Resources", which allows the developer to add links to external web pages. You may choose whether this URL is publicly viewable, and also the time period for which this link is active. Since AVML runs in a web page, a link to each of the lectures and labs is created, as shown in Figure 11.

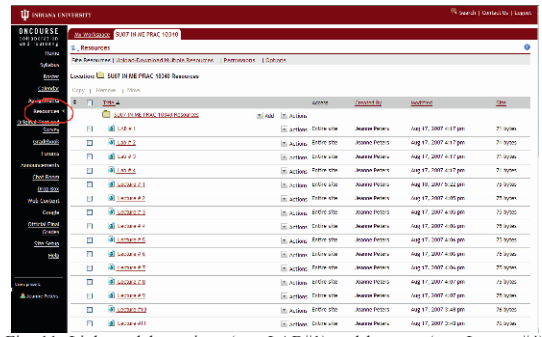


Fig. 11. Links to lab sessions (e.g. LAB#1) and lectures (e.g. Lecture#4) are shown

IV. ASSESSMENT OF THE LEARNING ENVIRONMENT

As part of process to validate the AVML as an effective tool for educating students and workforce in Advanced Manufacturing, an assessment plan was designed, which consisted of two main phases. In the first phase, the usability of the interface was assessed, while the second phase concentrated on the assessment of the content.

4.1 Usability of the interface

The usability study was designed and implemented to assess the ease of use of the instruction delivery tool,

mmeybodi@aut.ac.ir

namely, the AVML. The usability of the instruction (or course) management tool, OnCourse, has been evaluated by IU/Purdue students as part of course evaluation, over the past few years. As such, it is not addressed in this work.

The usability study of the AVML is a qualitative observational technique that can measure how well people can use an application [13]. The usability test devised involved observing the subjects attempting to use the AVML. The designed usability study had the subject perform various tasks in the lecture and the virtual environment sections of the AVML. While taking the usability test, the subjects were requested to "think out loud" in order to allow a better understanding of the thought-process of the user. At the completion of the usability test, the subjects completed a post-test survey to provide appropriate feedback. Figure 13 below depicts the usability testing setup for the AVML. The randomly recruited students were scheduled to take the test under supervision of at least two team members. The first team member (sitting at the testing station) observed the human subject and took notes; similarly, the second team member sitting at the other station took notes while recording the testing session using Breeze.

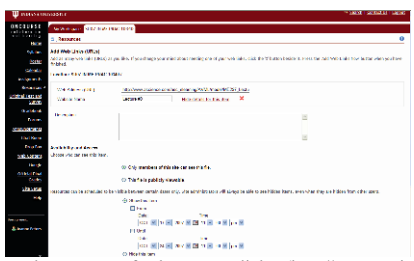


Fig. 12. The URL of the new link (http://www.ascience.com/asc_elearning/AVML/model/ME297_Lecture.htm?lecnum=9) is entered

4.2 Content assessment

The curriculum content of the AVML is assessed for learning effectiveness using a quasi-experimental study. The AVML, which provides educational content for theory (lecture) and specific machine tool applications (laboratory) related to CNC machining, is tested in two courses, one from engineering and one from technology. Students in these two courses served as subjects. Lecture materials and use of the CNC machine are provided in three ways (the treatments) throughout each course: traditional classroom training, virtual training using the AVML, and both. This framework is designed so that the effectiveness of the AVML can be compared to traditional classroom training, evaluated as a stand-alone tool, and as a supplement to traditional classroom training for both lecture and laboratory components. Analysis of variance is used to compare performance on both the lecture and lab tasks across treatments. After each training segment, student learning is evaluated. Evaluation of the lecture material consists of a test to measure mastery of concepts, and evaluation of the laboratory instruction consisted of a lab assignment to measure appropriate use of the CNC machine. Performance on the lab tasks is evaluated by two raters to minimize subjective bias. Data collection is still underway and results and findings shall be reported in the future.

V. RESULTS

Ten subjects have taken the AVML usability test that lasted 30 minutes in each case. The subjects were students from departments of Mechanical Engineering, Mechanical Engineering Technology, Computer & Information Technology, and Education. Table 1 gives a breakdown of number of students and their respective departments:

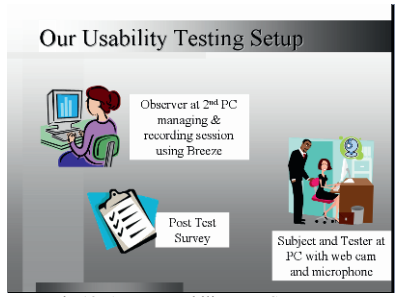


Fig.13. AVML Usability Test Setup

TABLE 1
HUMAN SUBJECTS

Subject's Disciplines	# of Subjects
ME	4
MET	1
CIT	2
EDUC	3

Figure 14 depicts a human subject performing one of the tasks of the usability study. The feedback provided by the subjects regarding the "ease-of-use" of the AVML is summarized in Table 2.

The results indicate the need for improving the ease-of-use of the interface. The additional feedback from the surveys was compiled and summarized to identify specific areas/aspects of improvement. On the one hand, subjects particularly liked the following features of the AVML:

- Use of "virtual space"
- Real life simulation of CNC machine tools
- Level of details that was incorporated in the AVML
- 3D representation of the lab
- Help obtained from the virtual agents
- Voice interaction

On the other hand, the major areas where the subjects had difficulty using the AVML were:

- Navigation through the lecture windows
- Navigation in the virtual lab environment

mmeybodi@aut.ac.ir

- Difficulty in learning commands for the virtual lab environment
- Finding information in the help menus
- Constrained window sizes
- Default position of the screen agent in the virtual lab environment window
- Need to resize the windows numerous times for navigating through different sections

The participants of the usability study also suggested improving the navigation through the virtual lab environment, incorporating a voice that is easier to follow, and improving the menu system. These concerns and recommendations were addressed during the redesign of the interface (Figure 15).

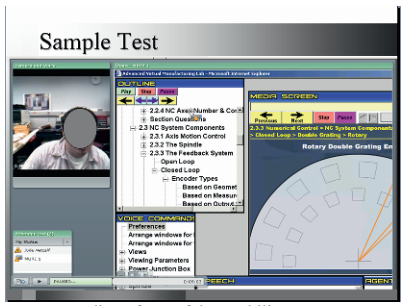


Fig. 14. Breeze Recording of one of the Usability Tests

TABLE 2
SURVEY RESULTS – EASE OF USE

Level of difficulty	**Number of subjects reporting**
Very difficult	0
Somewhat difficult	6
Neither difficult nor easy	1
Somewhat easy	3
Very easy to use	0

VI. CONCLUSIONS

In conclusion, this work has presented a state-of-the-art learning tool that seamlessly integrates instruction delivery with instruction management on the web. The resulting system provides unique capabilities in terms of delivering and management a typical engineering/science course with lecture and lab components fully online. “Introduction to Advanced Manufacturing” is an online course developed using such a technology.

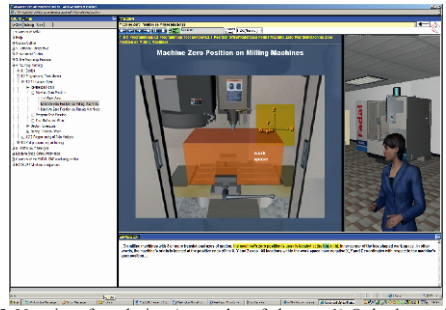


Fig. 15. New interface design (examples of change: 1) Only three windows instead of 5.; 2) Windows can no longer be manually resized; 3) New main window consists of both the multimedia window and virtual environment, with the default as shown here; however, when the user runs a training command, the window automatically switches to virtual environment only.

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mmeybodi@aut.ac.ir

Understanding Math Concepts Through Computer-Modeled Virtual Objects

J. Trujillo
P. Esteban
E. Montoya
R. Giraldo
A. Montoya
J. Mejía
H. Trefftz
Universidad EAFIT
{jtruji, pesteban, emontoya, rgirald4, amonto13, jmejiav3, htrefftz }@eafit.edu.co

Resumen

Information and Communication Technologies (ICT) can be used in order to motivate students to establish links between the classroom material and real life situations by modeling those situations through the course equations.

This article describes the results of an experience involving a group of Multivariable Calculus at Eafit University. 3D-Universal is the program developed for the experience, which runs on Pocket PC. It allows students to interact and communicate inside the classroom.

At each stage of the experience, students were asked to establish links between the classroom-covered material and real objects in their environment.

Keywords: modeling, student-instructor interaction, participative action, collaborative work, instructional environments, mobile-learning, Pocket PC.

1. Introduction

Calculus is a language allowing the expression and communications of relationships in various areas of knowledge. In Engineering, Calculus is a basic element, since students need to understand it in order to succeed in various application fields. For this reason it is important for students to find, from the beginning, the relationship of the subjects with their environment.

Multivariable Calculus starts with the study of equations of the form $z=f(x, y)$, which model various types of physical objects. For instance, when students graph equation $z = f(x, y) = cos(x)+sin(y)$ they realize that it looks similar to packages used to transport eggs. Quadratic equations can also describe physical objects such as balls, mountains and others.

The integration of Calculus objects and physical objects motivates the teaching and understanding of Calculus. On one hand, the instructor can guide the lesson around physical objects and, on the other, students can easily find meaning of various properties covered in the course

In such a class, technology can be used as mediator between mathematical an d physical objects, allowing students to (i) find the equation that describes an object or (ii) find objects that look like the math object. In both cases, students have to think about the following aspects:

- What type of equation to use.
- How the parameters in the equation have to be modified.
- Whether the surface has to be partitioned (or not) into various surfaces.
- Comparison of the virtual and physical object.
- Integration between virtual and physical objects starting from equations with multiple variables.

In developing the experience, we had to create the tools allowing students to realize the aforementioned activities.

In learning these new concepts, it is important for the student to build a diary in which to write how the knowledge is acquired and the relationships between the concepts and the real life world.

2. Software

Based on the Project needs, technology-related decisions were taken. The application is composed of a server which distributes messages among participants and the clients, which allows for the local manipulation of the virtual objects. The client runs both on Windows and Windows mobile.

The client code is multi-platform piece of software written in C++ and either OpenGL (for Windows) or OpenGL-ES (for the pocket PC). The server is written in Microsoft.Net C#.

A protocol was designed allowing the Exchange of various messages among the clients. Every message has to go through the server.

The client that the instructor runs allows more functionality than the student client.

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3. Use of Pocket PCs in the classroom

Mobile technologies are changing the way how math is taught in the University. It is now important to generate knowledge using technology as a mediator, allowing for a plural and integrating formation of the new professionals. In this context, the Multivariable Course at Eafit University is being used as a prototype allowing students to guide their own learning process through the collaborative work proposed by the instructor.

The instructor creates instructional designs allowing for the student-student and student-visualization interaction using the Pocket PCs.

The program allows students to (i) Plot 2D and 3D equations, (ii) solve derivatives and integrals symbolically. Students interact with the Pocket PC using the pen stick, rotating, translating and zooming on the virtual objects. Students can also add a plane, parallel to the XY, the YZ or the ZX planes. The application shows the intersection of the graph with the 3D surface. Using the software in the classroom allows the instructor to demonstrate graphs that would be very difficult to draw on the whiteboard, and to concentrate on the students' learning process.

4. Design of the Experience

The instructor starts the course with a description of the subject, the objectives to be achieved and the interactions that will take place using the Pocket PC.

The instructor then proposes exercises with increasing complexity, developing abilities to extrapolate the use of the knowledge to new areas. This process Foster the development of inquiry, deduction and abduction in the students.

The instructor plans the problems based on the students' analytical capabilities, as well as the building of relationships in context.

The instructor does not present a solution to the problem, but questions students that encourage collective analysis. Every so often, the instructor comes back to the concepts and generates anchor points before proposing new structures and knowledge. This process fosters the re-structuring and re-accommodations of previous concepts as well as the assimilation and accommodation of new knowledge.

In this process, the instructor proposes new mathematical concepts to the students. In doing so, he/she evaluates the understanding of previous concepts and existing structures. For instance, based on a situation in context (any physical object), the instructor ask students to come up with various equations that describe the physical object. This allows students to find links between equations an physical objects.

Students use the Pocket PC and the software in create a mathematical object [5]. The virtual object is rendered then and compared with the physical object. This process revolves around the understanding the student should achieve between the similarity of the mathematical and physical object. In this process, students have to structure the induced mathematical structure and reorganize their cognitive structure.

A traditional e-learning platform called "Eafit Interactiva" (EAFIT Virtual, www.eafit.edu.co/virtual) is used allowing students to use applets and to access other conceptual references to the concept at hand. The idea is not to obtain the correct answer, but to follow a procedure to validate the cognitive structure. This allows students themselves to find problems when solving the problems.

5. Proposed methodology

The learning process takes place through situations in which the cognitive equilibrium is temporarily challenged by generative questions. This process is guided in order to obtain learning situations around the mathematical concept at hand and physical objects in the students' environments.[2], involving actions of socializations, argumentation, re-signification of the object, all of this in the context of a zone of proximal development (as proposed by Vygotsky).

In this sense, the quality of this process is related to the actions of design, management and evaluation of the learning process. This quality is related to meaningful didactic transformations [3], in which the repetition of drills is not the principal learning axis, but in the contents in context allowing students to graph virtual objects based on a mathematical language.

Quality of learning is related to its effectiveness [4], i.e. how the student is able to operate with the given knowledge in order to solve mathematical problems and how the solutions are related to his/her environment. This implies, for the student, the understanding of the situation in context; to understand where to go with the solution and the implementation of mathematical operations leading to a coherent solution to the problem at hand.

The use of 3D-Universal, the software create for the experience, forces the student to develop his/her solutions from his/her understanding, instead of plain memory. In a similar way, the instructor uses problems in context, motivating the group to solve problems that have specific steps to find their solutions.

The process of expressing, formulating questions, explaining or sharing ideas include, among others [6]:

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- Validating other people's ideas or proposing additional ones
- Suggest new approximations
- Recognizing and establishing new theoretical links to support the argument
- Generating influences on the peers
- Assuming real ideas and authentic problems
- Exert validation and self-control with the aid of technology
- Generating knowledge construction as a group.

Questions are used as a fundamental knowledge to force students out of equilibrium, and then to re-structures and re-accommodate and assimilate knowledge. Questions create a situation that needs to be solved in "what if…" situations. The student proposes a possible solution without being questioned by the answer, whether correct or not. The instructor and the peers listened to the proposed solution. When the student becomes aware of the process, participates willingly and gets involved in the various drills. Ths student uses the Pocket PC as a tool to confirm and contrast. Direct exposition to the stimulus, generation or positive learning experiences, allows the student to learn new concepts, in a proper learning environment.

In this manner, questions become a guide and indicator of knowledge. After being questioned where the concepts arise from, the student adjusts his/her knowledge and creates new subordinate concepts which allow for a more flexible knowledge structure.

During the process of evaluation, results of the exams and home works are feedback for the instructor, allowing him to determine the students' cognitive structure. Additionally, questions that arise during the Project are answered by the instructor, forcing the student to become responsible for his/her answers, and peers become mediators. Answers arise from the previous experience, allowing the student to use previous knowledge to find his/her own solutions. Knowledge construction is, this way, based on autonomous processes, instead of on norms and regulations. Students learn based on autonomous motivation and feedback from peers and the instructor. They recognize that everybody in the group have made an effort and attention for building meaning from the application of theory to solve the problems at hand [7].

6. Modeling of physical objects by the students

Multivariable calculus allows for the modeling of physical objects such as spheres, ellipsoids, elliptic paraboloids, among others, or combinations thereof. For the realization of this process, students had to start observing their environments and establish links with the concepts in the course. In this case, three previous experiences were conducted:

- Observation of the environment. In this phase, students observed real objects outside of the classroom took pictures and compared the physical objects with the equations learned in the course. The first part is an inductive process that takes place in the students' environments. The second part is a deductive process comparing the objects with mathematical equations.
- Use of the 3D-Universal software in order to: Graph equations of the form $z = f(x, y)$ and relate them to objects. This is an adductive process. The student makes a hypothesis about the equation and uses the software to find, step by step, one related to the physical object.
- Bring physical objects to the classroom.

This previous Works is important for students to overcome previous math classes based only on the presentation of theorems and properties, with any contextualization with real life situations.



Figure 1. Some of the physical objects brought to the classroom.

7. Experience in the classroom

In order to realize the activity in the classroom, students created groups of two or three in order to answer the following questions:

- What type of equations models the physical object?
- What are the parameters that can be used in the equation to improve the fit?
- How can i use the software to graph the equation?
- How can I describe the equation from my own process of thought?

After the experience, each team has to create a single report explaining the process to reach a consensus of the equation corresponding to the physical object.

Students had access to: (i) Physical objects (ii) Pocket PCs with the 3D-Universal software (iii) textbook (iv) classroom notes and (v) advice from the instructor.

The instructor directed the students' attention to the following issues:

mmeybodi@aut.ac.ir

- Capacity of the group members for solving the problem.
- Types of equations used to model the physical objects.
- Use of the parameters of the suggested equations.
- Resemblance of the object with the resulting graph.

The whole process took place during a 90 minutes session in which students compared the knowledge they had to solve the problem at hand. Students revised the classroom notes, the types of equations seen in the course and the way how the parameters change the 3D graph. Collaboration among groups took place and was encouraged.



Figure 2: Group work in the classroom.

8. Results and evaluation

Groups were formed freely by the students.

In the beginning, students were surprised by the proposed activity, and said that they had never done such things in previous courses. But after a couple of minutes, they started working on the proposed activity. The software on the Pocket PC served to model the physical objects.

Group work encouraged discussion and negotiation of meanings in order to achieve conclusions about which equations to use and how the parameters have to be fine-tuned en each case.

After the experience, students had a better use of the technical language. Math classes, in general, do not encourage students to express with their own words what they think of a solution, nor to socialize this opinion with the instructor and peers. After the experience, math language was used with precision and fluidity.

Written evaluations were applied to a control group that did not conduct the described activities as well as to the experimental group. The evaluation was designed and conducted by a professor who is not part of the research team. In a scale from 0.0 to 5.0, the experimental group achieved an average of 4.0, whereas the control group achieved an average grade of 2.8. We consider that this difference in grade is related to the process of making sense of what is being studied in contrast to objects and situations from the environment, which directly affects the motivation of the students towards math as a language.

Some of the comments by students after the activity were as follows:

- "I had never thought of what the parameters in an equation really mean"
- "Now, wherever I go I am comparing physical objects with the equations in the course".
- "Before this experience, I had never thought of the importance of Calculus in my Engineering studies"
- "Before this course, I used the calculator to perform very simple operations. Now I see the potential it has to understand my environment".



Figure 3: Result of modeling physical objects with the 3D-Universal software running on the Pocket PCs.

9. Conclusions

The use of an appropriate pedagogical design and the corresponding integration with technology allow students to become highly motivated to understand and use the mathematical concepts for solving problems that are meaningful for each student.

10. Acknowledgements

The research team would like to thank Eafit University for the support to the Project named "Development and implementation of services and contents in mobile technologies to achieve collaborative work in university education", code13-000058. This Project provided the time dedication and resources that made this experience possible.

mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Knowledge Control Model of Distance Learning System on IMS Standard

H. Kravtsov, D. Kravtsov
Kherson State University, Ukraine

The results of designing and modeling of distance learning system on the base of international standards IMS, SCORM are represented. Distance learning system «Kherson Virtual University» is used for the illustration.

I. Modelling of distance learning process

Learning of the mechanism of knowledge control in different distance learning systems (DLS) has shown necessity of use of mathematical model at developing of distance learning system [1]. In particular, at composition of logic communication of learning layers in DLS Unified Modeling Language (UML) is used. Each layer is considered as set of the interconnected learning elements. The learning program is allocated with points of the control in which there is the branching of the program connected to learning on the following layer or return of the student to learn again.

Two types of conditions of the learning program branching are entered:

а) R – conditions of the outgoing control which realize process "restudy";

б) U – conditions of the incoming control which do not allow the student to get in the new block of lerning if he does not have necessary knowledge. The U-condition and corresponding tests become necessary in real computer learning where the cumulative knowledge should be fixed. The designer of DLS enables to set protecting U-conditions in view of a trained contingent structure and its heterogeneity in basic training.

The program (sequence of logic blocks during learning) is directed columns the tops of which are logic blocks, arches represent relations of direct following of studying of one block behind other. Logic connections are inside logic blocks. The program is marked by blocks of the top generalization layer, it begins from block l_0 and comes to the end to block l_k (Fig. 1).

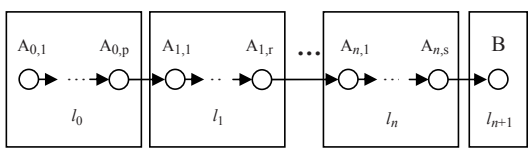


Fig.1. Learning layers in DLS.

Further, the program is marked by returns for repeated learning (restudy). Each logic block is supplied with the incoming and outgoing controls which are the predicates marking arches of return. Returns are located within the limits of one layer, the conditions of continuation of learning are marked by (*). The structure of returns is established by the designer of the learning program and maybe arbitrary according to the tutor choice (Fig. 2).

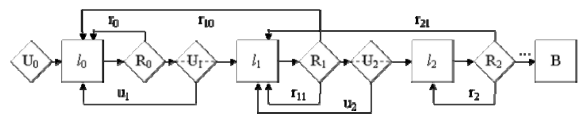


Fig.2. Studying model with using knowledge control in DLS.

Special blocks of learning (blocks of knowledge refinement) which are absent in the basic process of learning are entered and included only for an output on the following layer of knowledge refinement if the student practically does not acquire a material of the studied block. Thus, the program forces the student to pass learning repeatedly and then to return to a level from which the student is directed for learning again.

II. Specification of tests in IMS standard

Modern DLS should satisfy to the following organizational - technical requirements. It should support work of the software in any network, on any platform, have the Internet-compatible interface and keep the data in a standardized saving format of the educational information. Among these requirements the developing of uniform saving standard (format) is important for saving of educational information resources. Now the standard developed by organization IMS Global Learning Consortium, Inc. (IMS) is accepted [2]. Standard IMS contains open specifications of support of activity within the framework of the distributed learning such as accommodation and use of teaching materials, supervision over student progress, delivery of reports on progress of students and information interchange about students between management systems.

For storage of information resources, for example tests, in control systems of databases (CSD) at designing a database it is necessary to take into account the fact of the future converting of the data in files of the special format convenient for maintenance of transfer of these information resources in others DLS. Thus all fields of the metadata should be determined according to specification IMS.

To ensure communication between DLS which are constructed on various technologies and programming languages specifications IMS-LDP (Learning Design Packaging), IMS-CP (Content Packaging) are used. Taking into account volumes of the various information stored in IMS-Package and subjects of given article application of only specifications IMS Question and Test Interoperability Specification (IMS QTI) which describes structure and storage of tests is considered below. Patterns of the basic types of questions are considered in the report, the special attention is given to so-called objective and adaptive tests which are widely used in geographical information-educational systems.

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IMS Question Specification and Test Interoperability Specification versions 2.1 provides support over 20 types of questions in tests of distance learning systems. Each type of a question of the test has similar structure as all other types of questions. The diagram of a sample type question is submitted below (Fig. 3) [3]:

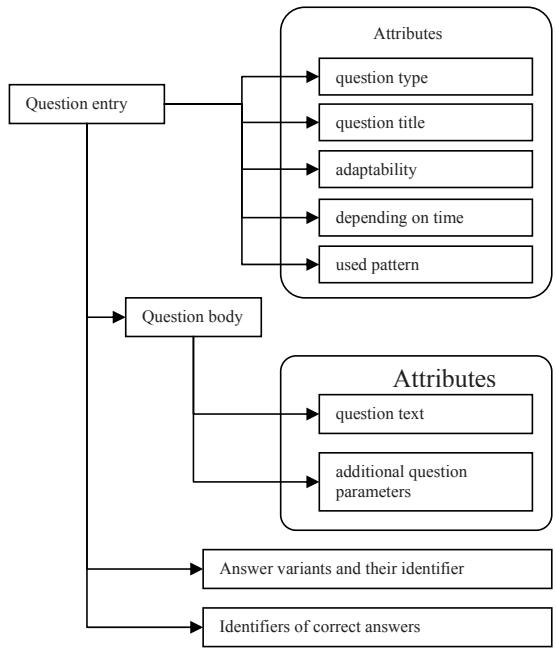


Fig.3. Diagram of pattern type question and its specification

The submitted pattern is abstract in relation to the majority of question types. Each type of a question has its own features in the specification. It is connected with parameter distinctions of these types.

Examples of the basic types of test questions are:

- . *«The Choice of one variant of the answer from many» (SimpleChoice)*in which tested student is offered to choose one variant of the answer from the several given answers for the certain question.
- *«The Plural choice» (MultipleChoice*) in which tested student is offered to choose some variants of answers from the several given answers.
- *«Ordering»(Order)* in which tested student is offered to order the given text objects.
- *«Conformity of pairs» (Associate)*in which tested student is offered to establish binary connection between the given text objects.
- *«The Hot point» (HotSpot)* in which tested student is offered to choose a point or set of points on the figure.
- *«Ordering of graphic objects» (GraphicOrder)* in which tested student is offered to specify the set of points order on the image.

The tested student answer is processed in the «Processing of the answer» (Response Processing) module. The answer rating in the module can occur by two various ways: 1) the differentiated rating of the whole question and 2) rating accumulation according to the answer variants.

In IMS QTI there is a description of question types which concern to group so-called «Objective elements» (Object Items) and «Adaptive elements» (Adaptive Items). According to IMS specification features of the given types consist in multi-stage passage of a test question during task execution. There is feedback with tested student which determines the answer correction at each stage and thus forms variability of the answer. In this question there can be additional parameters which are not specified under the standard. As an example of realization of such objective question interactive Flash-animation in which the certain task is programmed can serve:

- initialization of the module with some incoming parameters,
- an interactive game situation in which tested student takes part,
- the outcoming data as result of tested student action.

The result of the objective (adaptive) type question answer can be determined in object of test passage in view of value of the maximal rate of correct test passage and can be used at automatic (program) rating. As the alternative rating can be determined (changed) by the tutor at check.

We have considered examples of IMS standard tests with conclusion that a variety of test question types should be taken into account at designing of question and answer table structure in CSD systems, module «Processing of the answer», formation of question representation patterns depending on their type.

In summary as an example we shall consider types of test modules realized in DLS «Kherson State University» (DLS KSU).

III. Methods of realization of the program testing module in distance learning system

For demonstration of distance testing system on the basis of IMS standard realization of testing system in DLS KSU is used [4].

mmeybodi@aut.ac.ir

Program modules DLS KSU. Test examples.

At development of a database structure there is a necessity to provide the uniform interface of the tables connected with testing system. For this purpose in DLS KSU two modules with different purpose are created and realized in tables DBMS [5]: "Author's test" is a module which is intended only for filling in course documents with tests, for following use in learning groups. The given module is connected with the module "Author's course"; "Tests of group" is a module which is intended for carrying out of practical study in learning group on distance learning site. The given module is connected with the module "Learning group".

Database structure of testing system.

In DLS KSU each testing system module considered above contains database tables which diagram is shown on fig. 4.

Fields of each table depend on its purpose. For example, in the table "TESTS" of the system there are fields which connect tests with learning group and an author's course.

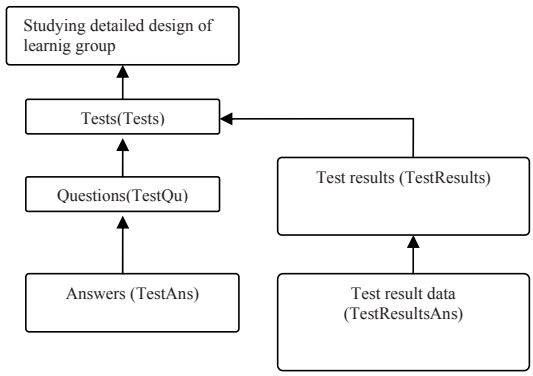


Fig.4. Table diagram in a testing system.

After passage of the test by the student the teacher has an opportunity to check the whole testing passage. Also the teacher can establish the necessary number of points for each question at the first check of testing results.

IV. Description of the Data Export – Import Process Between DLS

As it has been told above the data export - import process between various DLS passes with use of IMS standard specifications. The tool of such data carrying is the special module (class) which realizes a set of the methods which are carry out export and import of the data in special IMS determined data files. The general diagram of data export - import process has the following view (Fig. 5):

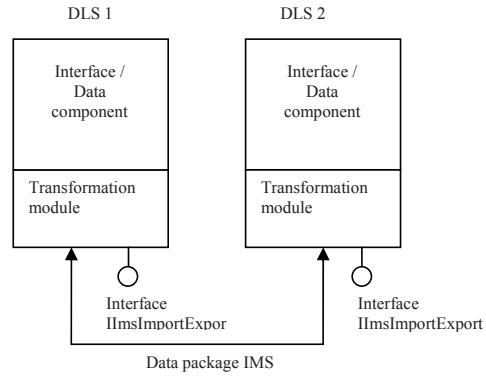


Fig.5. Diagram of data export- import process between DLS.

Apparently from the diagram on fig. 5 every DLS should realize the data and interface component and also the data carrying module which inherits methods of IImsImportExport interface. The description of this interface is shown below (Fig. 6):

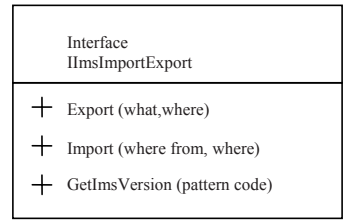


Fig. 6. Interface of data transfer

Thus, data export - import process between various DLS is carried out at two stages:

- data export to IMS format file from DLS 1;
- data import from IMS format file to DLS 2.

The data export to IMS format file is a method of a class which receives the data identifier (for example, test number in the database) on the input as parameter. On the output the method returns a ZIP-package consisting of files – resources of the required material and XML-file which is IMS-validated (true under specifications IMS). That is the given method realized in DLS 1 (Fig. 5) enables the user to create one ZIP-file which can be applied in any another DLS, compatible with IMS.

Data import from the IMS format file – inverse process relatively export. The variant of data import not only from a file, and also from other sources (such as web - service) is possible.

Except for the above described two methods there is third GetImsVersion method which gives the object - addressee the

mmeybodi@aut.ac.ir

information on the pattern versions supported inside the given system.

As a result, due to work of one interface three methods any DLS has an opportunity to transfer the teaching materials in other system and also to receive them keeping in its own database. Certainly the given operation is made in view of the authorized access and safety.

RESUME

Thus the modern distance learning system which is compatible with IMS standard enables to supervise learning quality by using testing system developed according to IMS QTI specifications. Such system provides compatibility with others DLS at a level of information learning resources.

The described model of the DLS «Kherson State University» knowledge control satisfies to IMS standard and solves the task of integration of various distance learning systems.

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mmeybodi@aut.ac.ir

Issues and Difficulties in Teaching Novice Computer Programming

I.T. Chan Mow
National University of Samoa
PO Box 1622
Apia
Samoa

Abstract: **The main argument promoted in this paper is that computer programming is a cognitively challenging subject and hence good instructional strategies are important in providing the student with optimal learner support. This paper examines some of the major issues in the instruction of computer programming as based on du Boulay's 1989 framework. For each area of difficulty, some potential solutions are proposed. Solutions are categorized as pedagogical, technological or content based. An attempt is then made to combine these potential solutions and best practices as found in the literature into a learning environment CABLE.**

I INTRODUCTION

Computer programming is a difficult and challenging subject area which places a heavy cognitive load on students ([1],[2]). After two years of learning programming, most novice programmers are still struggling to be proficient ([3],[4]). From an examination of current research in this field, it can be postulated, that one reason computer programming instruction seldom results in the successful transfer of problem solving skills lies in a lack of understanding about good instructional approaches in this direction ([5],[6],[7]). Hence, effective instructional strategies and optimal learner support mechanisms should be developed to provide learners of computer programming with the optimal learning environment that they need. The following section outlines the issues and difficulties in novice programming and the recommended solutions to these.

II ISSUES AND DIFFICULTIES IN NOVICE PROGRAMMING

The discussion on the nature and types of problems encountered in learning programming is based on areas of difficulty as identified by [8], but with some additional concerns as identified by the author such as the issue of resources. These areas are: (a) the cognitive requirements of programming; (b) syntax and semantics; (c) orientation; (d) the auxiliary skills needed for programming; and (e) resource constraints. It must be noted that these areas represent overlapping domains. Table 1 presents a summary of these five main areas of difficulty in learning programming.

A. Cognitive Requirements of Programming

The first area of difficulty in teaching programming relates to the cognitive requirements of learning programming. Learning to program is a cognitively demanding task ([9],[10],[11],[12]).

Table 1
Summary of the five main areas of difficulty in learning programming
Note: This categorization is based on du Boulay's framework, 1989.

Area of Difficulty	Dimensions/Aspects
Cognitive requirements of programming	Cognitive demand (Mental models)
	Precision
	Transition from novice to expert
Syntax and semantics	Closeness of mapping
	Consistency
	Error proneness
	Role expressiveness
	Secondary notation
	Hard mental operations
Orientation	
Auxiliary skills (Pragmatics)	
Resource constraints	

B. Cognitive Demand

Programming requires a programmer to hold a wide range of information in working memory. These include: (a) the details of syntax and semantics specific to the programming language used, (b) some mental model of how to solve the problem, and (c) the ability to differentiate between solving the problem and specifying the solution ([13],[14]).

C. Mental models.

Programming involves the construction of several mental models ([15]). Firstly, computer programs are written as a solution to some problem, and an understanding or mental model of this problem domain needs to be established before

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any attempt to write an appropriate program ([12]. Secondly, the programmer needs to construct a mental model of the "notional machine". "*The notional machine is an idealized conceptual computer whose properties are implied by the constructs in the programming language employed"* ([8]). Thirdly, the programmer must also develop a mental model of the program itself and how it will be executed ([11] [12]).

An effective instructional model should facilitate the building of effective mental models by strategies such as good modeling, coaching and scaffolding by an expert, the use of modeling tools and visualization techniques. Furthermore, multiple examples should be used to illustrate the behavior of programming models, so that students could use the examples to construct their own viable mental models ([15]). Constant repetition of examples illustrating a concept is needed for the construction of viable mental models. Another effective strategy, as an aid to the organization of knowledge, is the use of advanced organizers.

D. Cognitive load.

Programming requires the student to be proficient in the use of the development environment, mastering the use of the compiler, and interpreting responses such as result codes, error and warning messages. The need to hold this wide range of information in working memory, imposes a demanding cognitive load on the student ([16] [2]). Reference [2] proposes the use of instructional support materials such as worked examples, and partially complete solutions (implemented in part by a code restructuring tool) as strategies for alleviating mental load. The use of visualization techniques will also alleviate cognitive load. Examples include visual programming interfaces and visual debugging tools.

E. Psychological effects.

Learning to program is more difficult, complex and intimidating than simply using one [16]. Psychological factors which may affect student interaction with computers include: (a) unpleasant experiences with computers such as computer breakdown and data losses; (b) intimidating computer jargon or vocabulary; and (c) continually encountering problems that one is unable to solve, or even comprehend, sometimes leading to a state of "learned helplessness".

F. The Need for Precision

Another factor which contributes to the difficulty in learning programming is precision [17]. A high level of precision and specification must be maintained at all times, requiring a level of attention to detail that does not come naturally to human beings. At the same time, the programmer must deal with the limitations of language, machine, and compiler, all of which frequently require the inclusion of details that are not directly related to the problem, such as inclusion of libraries, and memory management routines.

An effective pedagogical model would emphasize the need for precision by extensive modeling, coaching and scaffolding with the use of multiple examples, and also the use of a debugger to identify program errors.

G. Differences between Novices and Experts

The learning process can be viewed as a process in where the learner progresses from a novice state to that of an expert. An investigation of the differences between novices and experts yields important information on how to teach programming to novices or beginners.

Firstly, novices have difficulty in recognizing incorrect grammar, and hence struggle with syntactic knowledge while experts readily recognize grammatical errors [18]. Secondly, in terms of semantic knowledge, experts have effective mental models of the virtual or notional machine, while novices have yet to build these models. Thirdly, in the area of schematic knowledge (knowledge of the structure of a program) experts use deep structure to categorize programs based on the type of routines required. In contrast, novices use superficial features for categorization.

Programming is described as the composition of plans or schemas [4]. Novices are inclined to use low-level plans, and are unskilled at problem decomposition. In contrast, experts keep an overall view of the problem in mind, while decomposing problems into small, manageable sub-problems. Experts also consider many more alternative solutions than novices, and are more adept at comparing different solutions and considering the merits of each [18].

H.. Notation: Difficulties with Syntax and Semantics

The second area of difficulty in teaching programming is the notation for representation of a program. Notation refers to the symbols of a programming language and the syntactic rules for combining them into a program [4]. Some of the dimensions or aspects of notation which affect programming ability are discussed below. These include: (a) closeness of mapping; (b) consistency; (c) error proneness; (d) role expressiveness; (e) secondary notation; and (f) hard mental operations. These will now be discussed in turn.

I. Closeness of Mapping

"Closeness of mapping" is a description of the closeness of the programming language to knowledge which students already possess, to the types of problems students should solve, and to the concepts students are attempting to acquire. A good instructional model would have techniques which would facilitate a closeness of mapping or a match between a student's existing knowledge, the problem which needs to be solved and the entities in a program. Useful techniques include the teaching of only a subset of the language, and the gradual expansion to include the full language as the novice programmer gains expertise in the use of the language [19], and the use of contextualized examples of programs in real world or applied situations.

J. Consistency

There are many forms of consistency, and programming languages require several of these forms in order to be

mmeybodi@aut.ac.ir

maximally usable. A programming language needs to be consistent with: (a) what programmers already know, (b) within the languages own constructs, and (c) with domain knowledge and terminology [20].

A common strategy used in teaching programming is the use of analogies. However, novices frequently encounter difficulty with the limits of the analogy and mistakes arise out of attempting to extract too much from it. For example, with the command readln (*odd, even*) and the input values "2 3", they expect the computer to read the values 3 into *odd,* and 2 into *even* [21].

A common analogy used in the teaching of programming, is where a variable is described as a box for storage. Hence, users sometimes think that a sequence such as "*a*=2" followed by "*b*=*a*" means that *a* no longer holds the value 2.

Such inconsistencies can be addressed through teacher mediation in making students aware of the limits of the analogy, and by highlighting and correcting such misconceptions during the course of programming instruction.

K. Proneness to Errors

A common limitation of most programming languages is its proneness to errors. Examples of some error prone programming constructs and concepts include starting array indices at 0 rather than at 1, and in Java, the use of " =" to test for equality of reference rather than equality of value.

To address this common limitation, an effective pedagogical model should emphasize and highlight these common sources of errors so that students develop an awareness of potential errors. Again, the use of worked and multiple examples would be beneficial.

L. Role Expressiveness

"Role-expressiveness" is the degree to which information about the function of a construct can be determined from its structure or form. For example, the Java keywords *println* and *readline* used for printing output and reading in input, are highly role-expressive as their functions are obviously apparent.

However, Java also has some problems with role-expressiveness. For example, the meaning of the keywords *static* and *final*, for example, are not intuitively obvious especially to novice programmers [10].

An effective model of instruction should be able to support role expressiveness by explicit instruction of the meaning of each of the syntactic terms in a language. An example of this would be the use of articulation where an expert articulates the meaning of the terms in a program, and the novices learn by imitating the expert.

M. Secondary Notation

Secondary notation is information within the program text which is not part of the syntactic structure of the program but is useful for the readability and meaningfulness of the program [22]. Examples of secondary notation include comments, white space, indentation of code, and highlighting of key words. Furthermore, training of programmers is necessary in order for them to utilize secondary [22]. An effective learning environment should provide instructional training of novice programmers in the efficient use of secondary notation in order to enhance the readability and subsequent comprehension of programs.

N. Hard Mental Operations

The complexity of programming is a contributing factor to its challenging nature and "hard mental operations" refers to concepts which are complex and cognitively challenging [4] Examples of hard mental operations for novice programmers include iterations, recursion and optimization problems. Formulation of effective instructional strategies such as scaffolding, coaching, and modeling [25]. is needed to help students master such complex and mentally challenging operations.

O. Orientation

Orientation refers to the difficulties students have in recognizing and identifying what the term programming actually means, what processes programming actually entail, and what it is useful for. In recent times, the term programming has increasingly been used to refer to a range of activities which do not fall within the realm of computer science definitions of programming. Examples include data manipulation on spreadsheets, programming in HTML and even "programming" a microwave or a VCR. Such developments have compounded the problem leading to further confusion on what programming actually is [9].

Secondly, because of the way in which computer programming has been taught, and where the focus has only been on learning the syntax and semantics, students are not orientated in the context within which programming occurs and can be applied in real life.

An effective instructional model should address this by incorporating a good introductory section on what programming is, and the different "types" of programming which abound. Furthermore, there should be an attempt to relate programming to its application in software development and somehow avoid a common defect in the teaching of programming where programming is taught in isolation and not related to its real life applications.

P. Auxiliary Skills

The fourth area of difficulty in learning programming is the demand for additional or auxiliary skills. Auxiliary skills necessary for programming include proficiency in dealing with the development environment such as the operating system interface of the computer, and also other technical skills such as editing, compiling, and debugging a program [23].

Hence, instruction in computer programming must also include training or instruction in such skills as file management, editing, compiling, and debugging of program code.

mmeybodi@aut.ac.ir

Q. Resources

Other issues in teaching and learning novice programming include the lack of quality instructional resources and the lack of teachers with sufficient background in teaching object-oriented programming [24]. This is certainly a common situation in most tertiary institutions worldwide, and is certainly the case within our programming courses, at the National University of Samoa.

There is also debate over how the object-oriented paradigm should be introduced, with such issues as "objects early", "objects late" being contested in the literature. However, studies seem to indicate that the pathway of teaching object-oriented languages by firstly teaching procedural programming is ineffective and hinders student uptake of object-oriented constructs ([4]; [23]). This then makes the case for teaching object-oriented programming at the introductory level, and also the suitability of the use of pure object-oriented languages such as Java

III ESTABLISHMENT OF A LEARNING ENVIRONMENT

The main argument that this discussion is based on is that an effective learning environment is crucial for improving student performance in computer programming. The four dimensions which comprises any learning environment are content, method, sequence and social context [26].The discussion so far has proposed solutions focusing on methods or pedagogies. However another important dimension of a learning environment is content.

A. Content

Content refers to the different or distinct types of knowledge required for expertise. Cognitive research distinguishes between four types of content knowledge: (a) domain knowledge, (b) heuristic strategies, (c) control strategies, and (d) learning strategies.

Domain knowledge refers to the concepts, facts and procedures in a particular subject area, usually found in textbooks, lectures and demonstrations. For example, for this research, this will be concepts facts and procedures associated with Java programming. When domain knowledge is taught outside its problem solving context, this knowledge remains inert and transfer of knowledge does not eventuate. Hence for this research the course reader was rewritten so that domain knowledge was taught within context of application. E.g., programming taught within the context of SDLC.

Heuristic knowledge or strategies are "tricks of the trade" or "rules of thumb" which are generally effective in solving problems and for accomplishing tasks. Examples to be used in the proposed environment are rules for instantiating objects in a Java program, trouble shooting procedures in debugging Java programs.

Control strategies is knowledge used when there is a need to decide between a range of possible strategies and to decide when to change strategies. Examples for the proposed environment include the use of plans, comparisons of different implementations, the use of trace tables for checking the execution and outcome of a program, and the use of a debugger to identify program errors.

Learning strategies refer to strategies used to acquire new concepts, facts, and procedures in their own or another field. Learning strategies can either be general or domain specific[26]. General learning strategies used in the proposed environment are collaborative learning, engaged learning, and situated learning.

Domain specific strategies include the use of "think alouds" for articulating the steps in instantiating objects, UML modeling, stepping through the program using the debugger, and using the visual representation of the variable stack within the debugger, to trace the values of variables, as the program code executes.

B. Technological solutions

E-learning is defined as a learning approach implemented by the use of a range of technologies such as pcs, CD-ROMs, mobile devices, Internet, and computer-mediated communication (CMC) techniques (e-mail, discussion forums, chat rooms and collaborative software).

The three main advantages to online learning are that students (a) can choose their own pace of study, (b) are able to organize their own schedule and not be tied to time and place, and (c) can choose a pace of study independent of others[28].

Advantages of computer mediated communication (CMC) in e-learning are as follows [29]. Firstly with CMC learners acquire knowledge within the context in which it is used. Secondly the use of CMC eliminates the problem of transfer of knowledge from the context of learning to the context of practice – situated learning. The third advantage is the motivation provided by the presence of a diverse real audience instead of just the teacher as in a conventional classroom[29]. Yet another advantage of CMC is the provision for a more diverse range of people to interact.

The main argument promoted in this paper is that an effective learning environment is crucial for improving student performance in computer programming. It is appropriate that content, and pedagogies recommended in the literature be combined with online technologies to produce an effective instructional model which could enhance the teaching of computer programming. Table 2 summarises the issues in teaching programming and potential instructional solutions.

C. Proposed Learning environment Model

The proposed learning environment is a combination of variety of contemporary best practices which makes use of cognitive apprenticeship, collaborative learning, metacognition, and technologies via the use of tele-apprenticeship and online or computer-mediated communication (CMC). The main driving assumption of this proposed learning environment is cognitive apprenticeship hence the name Cognitive Apprenticeship Based Learning Environment or CABLE.

Cognitive apprenticeship is directed at teaching processes that experts use to handle complex tasks, and is characterized by a number of teaching methods[4]. These include modeling,

mmeybodi@aut.ac.ir

scaffolding, coaching, articulation, reflection and exploration [27].

Table 2
Table of programming issues and possible instructional solutions

Issues in teaching programming	Potential instructional solutions
Cognitive requirements of programming	
Cognitive demand	Visualization (debugger) UML modeling Coaching Modeling Scaffolding Reflection Articulation
Precision	Scaffolding Coaching Modeling Debugger
Transition from novice to expert	Scaffolding Coaching Modeling Reflection Articulation
Syntax and semantics (Notation)	
Closeness of mapping	Situated learning
Consistency	Scaffolding Multiple examples Coaching Modeling
Error proneness	Scaffolding Coaching Worked and multiple examples
Role expressiveness	Articulation
Secondary notation	Coaching in the use of secondary notation
Hard mental operations	Scaffolding Modeling Coaching Reflection
Orientation	Situated learning Good introductory section on basic programming concepts
Auxiliary skills	Coaching in file management, compiling, debugging
Resource constraints	Construction of a reader Online notes

Another instructional strategy that is gaining prominence as an effective teaching method and is integrated into the learning environment being trialed is collaborative learning.

The starting assumption is that the computer can be used as a tool assisting in both cognitive apprenticeship and collaborative learning. An important element of the CABLE learning environment is its use of computer mediated communication techniques for implementing aspects of cognitive apprenticeship such as scaffolding, coaching, feedback and modeling [28]. Computer mediated communication techniques to be utilized in implementing tele-apprenticeship in the proposed learning environment include email, online notes, interactive tests and a bulletin board.

Hence CABLE is a hybrid model which uses both face-to-face and online mode of delivery. The components of CABLE are as follows:

- Cognitive apprenticeship
  - Modeling
  - Coaching
  - Scaffolding
  - Articulation
  - Reflection
- Computer-mediated communication
  - E-mail
  - Bulletin board
  - Online resources
- Collaborative learning

The transition from theoretical model to practical approach is made with the definition of the implementation details of the CABLE approach. The actual trialing of the CABLE environment is the subject of other papers ([30],[31]). In summary the present paper examines issues of teaching and learning novice computer programming, proposes instructional, content and technology based solutions and then combines these into the proposed learning environment CABLE with its key components of cognitive apprenticeship, collaborative learning implemented both in face to face and online mode.

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mmeybodi@aut.ac.ir

Activity Theory for Designing Ubiquitous Learning Scenarios

Jaesoon An
Knowledge Acquisition & Projection Lab
Pervasive Technology Labs at Indiana University
501 N. Morton St., Suite 212
Bloomington, IN 47404

Abstract – **This paper introduces ubiquitous learning and a methodological model called Learning Activity Model and associated procedures, which will help instructional designers to produce innovative ubiquitous learning scenarios.**

I. Introduction

Since the 1990s, educators have been trying to utilize wireless hand-held devices such as PDAs, mobile phones, palmtop and laptop computers, and more recently I-Pod as educational tools. Cases of implementing mobile wireless network and related curriculum and achieving improvement in learning and teaching with typical students and those with special needs have been reported [1], [2]. Some of the benefits of these mobile technologies for education include note taking in field observations, just-in-time access to needed information on the Internet or the server, immediate file sharing, and effective tracking and management of assignments, grades and other learning progresses [3].

Such learning on the go supported by hand-held devices can now be further enhanced by ubiquitous computing technologies into ubiquitous learning. Ubiquitous technologies are characterized by objects or places in the real world that have digital identifiers. The identifiers are in the form of tags such as RFIDs. Tags have memories which sometimes carry attribute information in addition to the identifier code. Other times when the tags do not have enough memory, attribute information is stored in remote databases and accessed via computer networks. Wireless hand-held devices can carry tag readers that communicate with the tag and the remote database, and then transmit the identification and attribute information to the user. Sakamura and Koshizuka [4] contend such a ubiquitous computing infrastructure is a next generation information and communication technology infrastructure for general purpose, just like the Internet. As the Internet has become a very popular tool for learning and instruction, ubiquitous infrastructure possesses similar potential.

Another great potential for education of the above mechanism of ubiquitous technologies, besides the opportunities arising from mobility, is the realization of augmented reality by superimposing digital information onto the real world [5]. Real objects and places such as museum displays and historic buildings can now carry multimedia information about them through a tag. Then learners can walk around them and access the tagged multimedia information. In this environment, learners' actual observations in the physical world stimulate them to look up information and the retrieved information vice versa motivates them to examine the physical world more closely or from other perspectives. Learners become motivated and engage in active pursuit and construction of knowledge in the process. Indeed, Schrier in Dieterle et al. [5] reports that students' motivation for learning and hence learning effectiveness increased significantly when the students were asked to perform learning activities based on the seamless integration between real objects and digital information. This kind of learning process is exactly what contemporary learning theories describe how learning takes place. Currently, many educators believe that learning occurs when learners themselves actively construct knowledge in the process of performing meaningful or situated activities [6], [7].

II. Activity Theory as a Theoretical Framework

When learning is viewed as an outcome of meaningful activities, methodological implications for learning and instruction can be derived from activity theory. Activity theory is a socio-cultural and socio-historical lens through which we can analyze most of human activities by examining the interaction of activities within its relevant environmental context [8]. In this theory, activity is considered as different levels of actions such as operation, action and activity in which an individual or a group of people (i.e., subjects) engage with physical or mental products (i.e., objects) to achieve intended outcome by utilizing tools or instruments and within the context governed by rules, community and division of labor [9], [10].

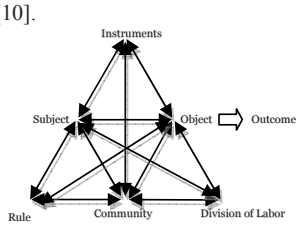


Fig. 1. Activity system [10]

The above mechanism of activity implicates that we can facilitate learning activities and hence learning by providing learners with appropriate objects, tools and contexts, i.e., scaffolds. Not surprisingly, many educational research

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 205–209.
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mmeybodi@aut.ac.ir

attempts are being made currently to provide learning scaffolds, most noticeably in the form of virtual environments and games [11], [12]. Also, some researchers have already tried to adopt activity theory as a methodological framework for designing constructive learning environments [8] or computer-supported collaborative learning activities [13], [14].

Activity theory also bears close relevance to ubiquitous learning. The theory's emphasis on socio-cultural scaffolds, in addition to the emphasis on activity, is repeated in ubiquitous learning where learning opportunities stem from collecting real-world context information and then incorporating them into learning activities. Whereas the context identification is enabled by computing technology, integration of the identified context into learning is enabled by instructional design artifacts, learning and instructional scenarios, i.e., ubiquitous learning scenarios.

III. Ubiquitous Learning Scenarios

Dieterle et al. [5] contend that wireless hand-held devices facilitate sophisticated instructional designs that are generally grounded in constructive learning theories. New learning opportunities enabled by mobile and ubiquitous technologies are likely to increase when educators actively design and implement innovative learning and instructional scenarios. The Reliving the Revolution (RtR) research study at MIT showcases a very effective scenario [5]. In this research, participating learners travel across the present-day site of the Battle of Lexington, holding GPS-enabled wireless handheld device. When the learners walk into pre-programmed locations, they encounter one of four historic figures who have different perspectives from each other (e.g., British Regulars, Miniteman soldier.) Then the device displays information given by the programmed figure on the social, historical, economic, geographic and political processes relevant to the Battle of Lexington and the American Revolution. After collecting such fragmentary, inconsistent and possibly biased information from different virtual figures and their own observations, the learners interpret the data to construct an evidence-based opinion about which side fired the shot that initiated the battle. Finally, they meet in a group and collectively debate what they think happened at the Battle of Lexington. In addition to the GPS-enabled handhelds, the research project provides scaffolds of the reasoning and procedural skills required of a historian to help with the learners' interpretation of data. It also allows for the teacher to act as a guide and resource throughout the whole process.

The above kind of learning scenarios can be realized not only through GPS-enabled handhelds but also through a profound instructional design employing instructional strategies and scaffolds that will induce constructive learning. Then how can we design innovative scenarios similar to the RtR scenario? Are there any methods that will help us to produce them effectively? This paper introduces a methodological model and associated procedures for designing ubiquitous learning scenarios based on the theoretical foundation of activity theory. These methods were initially developed by the author and her colleagues to produce service scenarios that would envision the direction and kinds of future products of Samsung, a global manufacturing and service company [15]. The model was titled originally as Human Activity Model as it targeted general activities that people perform. This paper intends to focus on learning activities; hence, the author customized the model specifically for learning activities and modified its name to Learning Activity Model.

IV. Learning Activity Model (LAM)

In traditional instructional design methods such as the Instructional System Design (ISD) model, designers usually start the design process by conducting a series of analysis to understand the audience, the task and goal, and the environment [16]. During that process, designers usually feel the need to have guidelines or principles on how to conduct each analysis effectively. Some theories are available to help with that. For example, Keller's ARCS model [17] describes dimensions of learning motivation so that designers can collect data on those aspects when trying to analyze the audience and the appropriate task for them. Hierarchical task analysis [18] is available to help with task analysis, and so on.

The Learning Activity Model (LAM) is a comprehensive framework that describes what to analyze when designers are preparing to produce scenarios. LAM prescribes that designers must identify Basic Activities (BAs) in the beginning of the design process. BA is a unit activity that learners think of and speak of intuitively. For example, when identifying BAs for teaching collaborative writing, the activity of using a word processor can become a BA when target learners do not know how to use it, whereas this BA is not required if they already know. In other words, when planning for teaching collaborative writing, teaching how to use a word processor can become one of many components of the whole process, hence a BA. In addition, people usually consider it as a unit activity by saying, for example, "in order to write collaboratively in an efficient manner, it is good to use a word processor." When teaching how to use a word processor is the objective, instead of the collaborative writing, it becomes a Goal rather than a BA. Then, its unit activities (i.e., BAs) become more specific activities such as teaching how to format paragraphs.

As implied in above description, the identification of BA does not take place by itself but in conjunction with the identification of other components of the model. BA itself, kinds or variants of BA (i.e., BA Kind) and their steps (i.e., Activity Step) fluctuate depending on the goal, the target learner, the time, place and other situational factors of the activity, and even the objects and instruments that will be used while the activity is being performed.

Goal can have Sub-Goals as in teaching collaborative writing being the goal and teaching how to use a word processor, one of sub-goals, when learners do not know how to use it already. When developing educational scenarios, designers usually start with or are given with the goal and the target learner. Based on these two pieces of information, they can identify sub-goals and the Situation the target learners are

mmeybodi@aut.ac.ir

situated in. Situation may include many different contextual aspects but most commonly, the Time when and the Place where the target learner will be situated while BAs are being performed, the Object on or with which they will engage BAs, and social aspects that activity theory describes, that is, rules, community and division of labor.

Last but not least, designers need to plan tools that will help learners to perform BAs successfully (i.e., Instruments.) Instruments can be helpful and hence necessary while the learners are preparing to perform BAs, while they are performing them, and after they performed. Similar to the situation, instrument can be comprised of many different components but most commonly, Knowledge Bases, Preference information and Plan during the preparation phase, Tools, Supplies and Data during the performance phase, and State and History information during the after-performance phase. Detailed descriptions of each kind of these instruments can be found in earlier report [19].

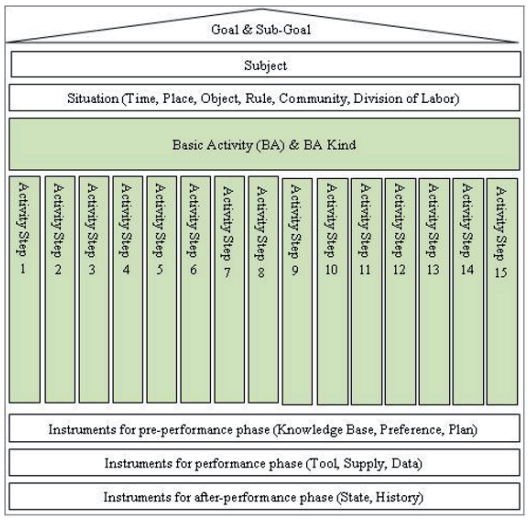


Fig. 2. Learning Activity Model (LAM)

The overall structure of the above Learning Activity Model derived from a theory, the activity theory. However, the content that constitutes this framework are identified usually through empirical studies. Given the goal and the target learner, designers need to conduct studies such as interviews and document analyses to identify necessary BAs and their kinds and steps, sub-goals, situational factors, and instruments. The common examples of the situation and the instrument listed above, for example, were derived after conducting observations of 2 families, in-depth interviews with 16 people, surveys from 640 people and numerous interviews with the experts in everyday human activities.

A major difference of the LAM model from the traditional ISD model is that analyses start by identifying unit activities. This corresponds with the emphasis on activities, which contemporary learning theories and ubiquitous learning place. Designers are encouraged to pay more attention in designing meaningful activities than producing lengthy Analysis, Design, Development, Implementation and Evaluation (ADDIE) documents. Another distinctive feature of LAM is that the set of guidelines included in the model is based on a single theory. In traditional instructional design practice, there is no single theory that is comprehensive enough to provide guidelines on all of the necessary analyses. Designers had to pull together guidelines based on different theories and hence the synthesis and the resulting design tended to be arbitrary.

V. Designing Ubiquitous Learning Scenario

The data collected and analyzed by following the LAM model can become a good starting point for composing scenarios. However, these empirical data come from investigating current ways of performing activities or wishes of people based on current practices. When the final scenarios are expected to envision innovative or novel ways of teaching and learning that utilize emerging technologies, as in ubiquitous learning scenarios, analysis results need to be augmented by the ideation on future learning styles enabled by new technologies. This kind of ideation or brainstorming can be performed by investigating what kind of new learning styles are promoted and what the new technologies can do about them, that is, implications of new technologies for contemporary education. Potential of ubiquitous technologies for education that were described briefly in the beginning of this paper, that is, opportunities arising from mobility and augmented reality are some of the dimensions that can be incorporated into this ideation. In addition, Dieterle et al. [5] contend that "neomillennial" learning styles propagated by wireless handheld devices are characterized by three benefits: fluency in multiple media, learning based on collectively seeking, sieving and synthesizing experiences rather than individually locating and absorbing information from a single best source, and active learning based on real and simulated experience that includes frequent opportunities for reflection. Dimensions such as these can become a guiding vision for the designers intending to produce ubiquitous learning scenarios.

Once designers analyzed for each component of the LAM model and decided on the desirable ways of learning and instruction through the ideation, they can now synthesize the research results into a scenario. Scenarios may be presented in a table format comprised of indices and values [20]. However, one of the most effective and commonly used formats in instructional design is storyboarding [21]. Storyboards are typically comprised of a series of drawings and narrative texts that explain what the drawings represent and the interaction among the features within and between drawings.

As for specific procedures for composing storyboards with the research data, they will emerge differently depending on the designer's conceptualization on the data and her strategies of synthesizing them. An example set of procedures emerged when the author and her colleagues were producing tens of scenarios. First, there emerged a need to organize analysis results in a standard format so that all the data related

mmeybodi@aut.ac.ir

to one BA can be found easily. Second, it was found that a learning scenario is usually composed of a series of BAs, rather than one individual BA. Some BAs were linked or related to each other because of their relationships in input and output information, and some, because of the chronology of the time and place where they are typically performed. Hence, information sequence and passage of time and place became the strategies for linking BAs. Last, the ideation results on the desired learning and instructional styles and the potential of employed new technologies needed to have reality checks. In order to design a scenario that can actually be implemented, planned technologies such as devices, networks and their infrastructure, and human-computer interaction strategies must actually be available or feasible to build newly. In addition, humanitarian issues concerning the technologies, such as security and privacy, social acceptance, and usability must be addressed in the design.

VI. An Example Ubiquitous Learning Scenario

Figure 3 and 4 below show frames in a learning scenario that was designed by following the LAM model and the procedures described above. This learning scenario envisions using a ubiquitous handheld device that helps family members to improve communication among them. Data such as frequency and content of conversations, voice tones in the conversation, duration of the time spent together, emotional states of the avatar representing each family member, and family event schedule are collected through the device and cross-referenced in analysis. Then, summary of the collected data and analysis of what the data may mean, become available on the screen. In Figure 3, the analysis shows that the family's overall level of communication is 25 out of 100 points and that between mom and dad, 45. It is also analyzed that a teenage daughter is struggling due to the shortage of communication with family members.

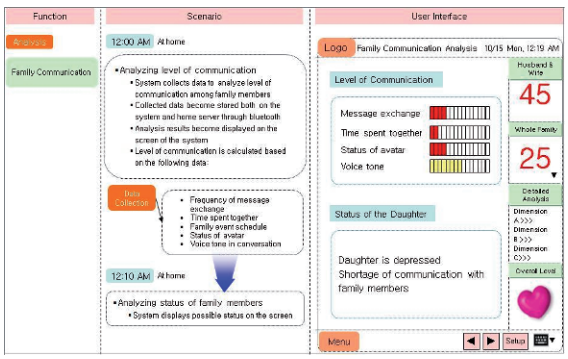


Fig. 3. Ubiquitous learning scenario: Collection and analysis of communication among family members

Figure 4 shows one of the interventions that can facilitate communication among family members. It is a game based on De Bono's Six Thinking Hats method [22]. Each family member chooses to wear a hat and plays a role represented by the hat. Someone wearing a white hat provides information relevant to the topic of the conversation, a red hat, talks about feelings related to the issue, a blue hat, manages the conversation process, and so on. By wearing different hats in turn, each family member gets to have a chance to think about the same issue in different perspectives. The device also records what has been discussed during the game and provides a summary at the end.

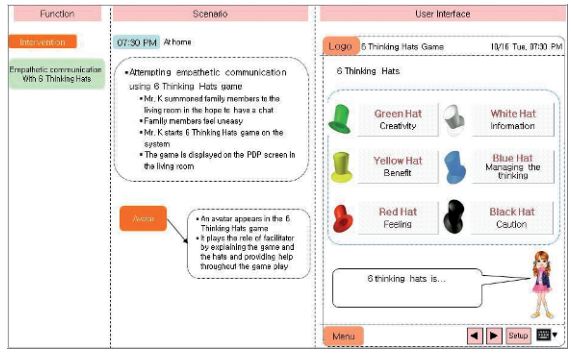


Fig. 4. Ubiquitous learning scenario: An intervention for improving family communication

VII. Conclusion

Mobile learning can be extended into ubiquitous learning by utilizing emerging ubiquitous technologies. Ubiquitous learning promotes the kind of learning contemporary learning theories describe, that is, active construction of knowledge by the learner. In ubiquitous learning, learners perform meaningful activities in the environment where the physical world and the digital information are seamlessly integrated with each other. With its emphasis on activity and context, ubiquitous learning shares a theoretical basis with activity theory and can derive methodological implications from the theory. The realization of ubiquitous learning can be achieved partly by computing technology's ability to collect and process context information but also through learning and instructional scenarios that integrates the identified context into learning activities. This paper introduced the Learning Activity Model based on activity theory and associated procedures for designing ubiquitous learning scenarios.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

An Inexpensive Approach for a Scalable, Multi-Boot Computer Lab

James D. Feher and Kumud Bhandari
Computer Science Department
McKendree University

ABSTRACT

Just as a community benefits from a diverse population, students can benefit from experiencing a variety of Operating System environments. Valuable tools can often exist on one platform that are not available on all platforms. However, with limited resources, it can be challenging for institutions when attempting to provide multiple platforms for their students. This paper demonstrates how a lab can be maintained and configured to boot multiple Operating Systems using open source tools. In this example, all operating environments except Windows XP are kept invisible from general users to avoid confusion. While Windows is set to boot by default, the systems can also boot various Linux based systems such as a thin client with Linux Terminal Server Project (LTSP), ROCKS clustering software and open source partition imaging software for maintenance.

Keywords: Multi-boot, versatile computer lab, Linux, ROCKS cluster, Linux thin client

I. INTRODUCTION

Allowing students to be exposed to multiple Operating System (OS) platforms can provide a wide range of experiences as well as expanding the tools available for them to use. Unfortunately, for many institutions it is not economically practical to dedicate the resources necessary to provide this type of exposure. Laboratory resources, including the computer hardware, as well as the space needed for the lab, are often in short supply. With the wide acceptance of the Windows platform for general campus users, it is often dictated that labs be configured with this OS.

However, it is still possible to provide a variety of OS platforms by configuring a lab to boot multiple Operating Systems using open source tools. In this paper, the systems will be configured to boot Windows XP by default with no option for any other OS. Other OS options will be obtained through the use of a boot CD-ROM. A boot loader could have been installed on the hard drive to boot Windows XP by default with options for other platforms without the need for a CD-ROM. It was felt that the confusion for general laboratory users could be reduced by ensuring that any Operating Systems other than Windows only boot using a CD-ROM.

This paper highlights the issues with installing the various platforms: Windows XP, ROCKS Linux Terminal Server Project (LTSP) and the System Rescue CD [1]. Of course, other distributions of Linux such as Fedora, Suse or Ubuntu could have been chosen and added. However, it was felt that the choice of Operating Systems provided a diverse set of environments: a Linux thin client in LTSP, a parallel programming environment with the ROCKS clustering software and a standard Windows setup for the general population. The open source program Partimage provided on the System Rescue CD was used to create disk images that could be used to archive and reinstall each partition instead of reinstalling the entire OS on each individual system [2]. This greatly reduced the effort required in maintaining the laboratory.

II. DISCUSSION OF VARIOUS OPERATING SYSTEMS

Since documentation for installing all of the systems discussed here is readily available, only the issues that arise as a result of attempting to boot all of the Operating Systems on a single platform will be highlighted here.

2.1. Linux Thin Client: This provided a solid Linux platform for students to use. As it is a thin client, it can run acceptably on a wide array of hardware with no impact upon the hard drive [3]. Because of this, configuring the system to use LTSP is one of the less difficult parts of the project. All that is required to run this thin Linux client is an external LTSP server available on the network and bootstrap code that is configured to run from the boot loader. Configuring an LTSP server will not be discussed here, as this is well documented [4].

The configuration of the boot options for LTSP can be done in several ways. First, the files necessary for this can be obtained in the etherboot package [5]. One may need to install this on the Linux system to obtain the proper files for the network cards on the system. For example, on a Fedora Core system, the command "`yum install etherboot`" will install the etherboot package along with the necessary files. More preferably, an International Student Organisation (ISO) can be generated using software available from ROM-o-matic through download or through a web interface [6]. This second method allows for more detailed configuration of the boot options. The software provides a vast array of configuration options available for generating the image, with nearly all of the default selections able to generate a working ISO image. Two particular options should be

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 210–215.
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mmeybodi@aut.ac.ir

selected, one providing proper network drivers for the computer hardware and other providing selection of an alternate port number for the Dynamic Host Configuration Protocol (DHCP). A wide array of network drivers is available. One of those should match the computer hardware in most cases. Secondly, as the ROCKS clustering software already contains a DHCP server, in order to reduce the conflicts between an LTSP server and the ROCKS server, the LSTP server should be configured to use an alternate port for DHCP. This will require a special configuration selection when creating the ISO image which is available when using the ROM-o-matic software.

2.2. ROCKS Cluster: National Partnership for Advanced Computing Infrastructure (NPACI) ROCKS is a collection of open source software for building a high-performance cluster [7]. ROCKS provides an excellent environment for students to learn parallel programming using MPICH, a freely available implementation of the Message Passing Interface [8]. Moreover, Cluster computing using ROCKS allows computationally intense problems to be solved using inexpensive commodity hardware rather than expensive custom-built hardware. Compared to other supercomputers, a ROCKS cluster has the advantage of scalability, meaning its size can be increased or decreased without interfering with the currently running processes [9]. Moreover, the computers constituting it can differ significantly in hardware configuration which makes it much easier and more feasible to set up [10].

2.3. *Installation of ROCKS*: The implementation discussed here consists of a master node (a dual core machine), several dedicated nodes, and lab computers capable of running multiple Operating Systems as remaining nodes. After setting up the hardware, network connection and installing the master node as described by ROCKS documentation [11], the nodes need to be configured via the master node to accommodate multiple Operating Systems on nodes. ROCKS, by default is configured to expand to the whole physical drive on which it is installed. This configuration can be changed as described here to make room for other Operating Systems. On master node, a file with filename:

`replace-auto-partition.xml`

inside the directory

`/home/install/site-profiles/"ver"/nodes/`

has to be created. Then, one needs to specify the amount of space in Megabytes that will be allocated to ROCKS installation on nodes. A sample of this file is provided in Figure 1 [11],[12]. Note that in this implementation, the physical drive had a capacity of 80 Gigabytes.

```
<main>
  <part>
     / --size 8192 --ondisk hda
  </part>
  <part>
     swap --size 1024 --ondisk hda     </part>
  <part>
     /state/partition2 --size 1
     --grow --maxsize 30720
     –-ondisk had
  </part>
</main>
```

Figure 1: Sample replace-auto-partition file.

Another important default setting that has to be changed is the ROCKS auto-reinstallation setting. ROCKS, by default, is configured to reinstall itself on cold boot [11]. In this course of action, it re-formats the physical drive, removing other Operating Systems. To change the setting, one should copy the file

`auto-kickstart`

from

`/home/install/rocks-dist/lan/"arch"/build/nodes`

to

`/home/install/site-profiles/"ver"/nodes/`

and rename it as

`replace-auto-kickstart.xml`

Next, one needs to remove the following line from the file [11]

`<package>rocks-boot-auto<package>`

The distribution to be installed on the node needs to be bound again by running ROCKS command:
`rocks-dist dist`

at the directory

`/home/install` [11].

On multi-boot nodes, ROCKS was installed first and other Operating Systems next.

mmeybodi@aut.ac.ir

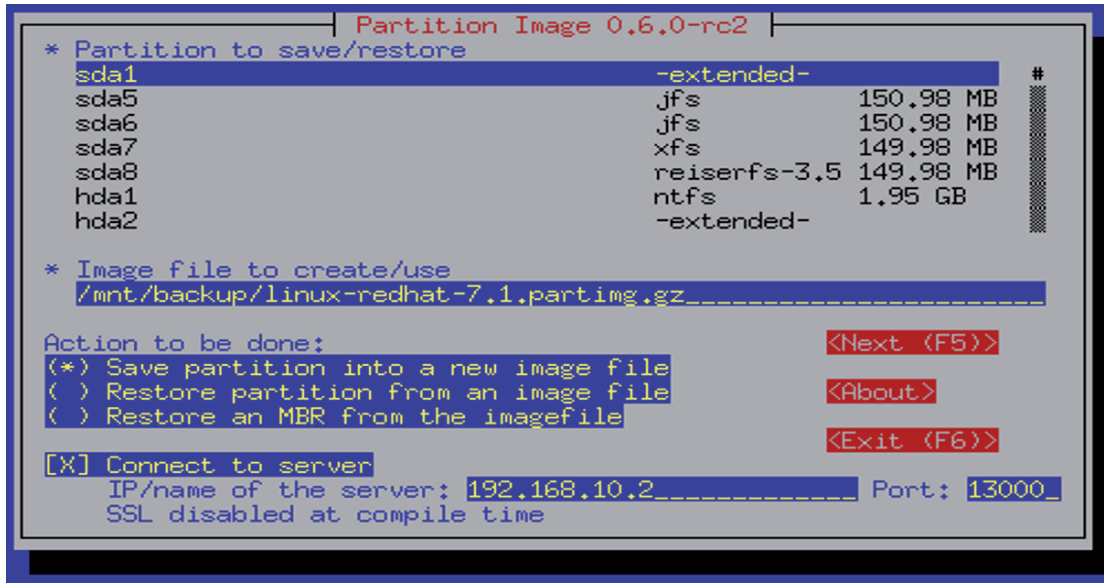


Figure 2: Screenshot of Partimage client interface [16]

2.4. Windows XP: Although NTFS support provided by Partimage is listed as experimental, replicating Windows XP with Partimage has been tested and works well [2]. However, if the windows image created using one primary partition (e.g primary partition 2) is used to restore different primary partition (e.g. primary partition 4), then Windows will not start properly. Partimage copies the partition, but it does not change the pointer in the various locations that specify where the image resides, such as the Master Boot Record (MBR), or the Windows boot.ini file. When preparing the image for archival, make sure to use the Microsoft utility Sysprep [13]. This utility helps to insure that settings in the OS are configured properly to ease the imaging process.

In this implementation, the ROCKS clustering software was installed first on each system with space left on the hard drive for the Windows installation. The remaining fourth partition was setup as a primary partition to contain Windows. An image of Windows XP was copied onto that partition. Lastly, Windows recovery console was used to restore the MBR using the command FIXMBR being run after booting from a Windows installation CD. This ensures that the MBR points to a partition where Windows resides. ROCKS by default will install itself in the first partitions of the hard drive, as does Windows. As mentioned earlier, in order to reduce the issues that arise during imaging of the Windows partition, one should prepare the image by installing the Windows on the same primary partition as it will reside on the final system after restoration, in this case the fourth primary partition.

2.5. Additional Operating Systems: Additional Operating Systems can be added to this configuration. As long as space is available on the boot CD-ROM, additional live platforms can be added to the boot CD-ROM with no impact upon the hard drive. Note, that if additional systems are added that would boot from the hard drive, the hard drive must be partitioned with extended (logical) partitions to allow for this.

III. IMAGING OF COMPUTERS

Proper maintenance of a computer lab, while necessary, can often be viewed as a tedious process. Commercial products such as Norton Ghost can be used to reduce the effort required to insure that all computer systems are configured properly [14]. Imaging systems allow administrators to install and configure one system, store an image of this system and then replicate it across an entire lab. Images can also be used to minimize the effort required to replicate systems that have been corrupted.

Several open source solutions, such as G4U and Partimage, exist which can accomplish the same task [15]. In this project, Partimage was used. It can copy entire disk partitions and save them on a remote system through the use of the Partimage client and server programs. Partimage is able to work with many different file systems, such as ext2/ext3, Reiser3, FAT16/32, HFS and NTFS. Partimage requires minimal overhead, providing a text based client interface which is seen in Figure 2. It is well documented and its use is fairly straightforward. Images can be stored locally, remotely or using removable media. In this case, it was decided that storing the images on a remote system was the best option, as this provided a central repository for the storage and back-up of fairly large images. Partimage comes as part of the System Rescue CD, which was put

mmeybodi@aut.ac.ir

on the boot CD-ROM produced for the lab. This allowed a single CD-ROM to be used for not only creating and restoring system images, but also for booting the various non-Windows Operating Systems.

In order to use the software remotely, obtain Partimaged, the Partimage server program. Run it on a separate server which will contain the images. While it has the ability to encrypt all data exchanges using Secure Sockets Layer (SSL), the version provided on the System Rescue CD has this option disabled by default. Therefore, when using the client version of Partimage provided by the System Rescue CD, make sure to use a server version that also has been configured to disable the use of SSL to avoid conflict [2]. Disabling encryption for the exchange of the images was not a concern in this implementation. If encryption is desired, a different version of Partimage will be required than the one provided by the System Rescue CD. This will require a different bootable system than the one provided by the System Rescue CD

IV. CREATION OF BOOT CD-ROM

With the Master Boot Record pointing to boot Windows XP by default, a boot CD-ROM needed to be created that would allow for other platforms to be booted. A guide to creating a Grand Unified Boot Loader (GRUB) boot CD can be found in the GRUB manual [17]. As mentioned earlier, the Grub boot loader could have been used on the system hard drive to boot ROCKS and Windows XP along with other platforms [18]. For this implementation, it was felt that it was best to totally remove any option to boot another OS. This eliminated the concern that the general population using the lab would become confused by accidentally stumbling across another OS. It also prevented users from somehow disturbing the configuration of the other platforms. While documentation on GRUB explains the creation of a boot CD-ROM, in order to include additional OS platforms, code from the ISO-Images for the additional platforms will also have to be incorporated into the CD-ROM. Configuring these packages can prove challenging. So, please make sure to consult documentation on this process [19].

For the boot CD to be able to boot an OS, the following files need to be present on the CD inside the `boot/grub` directory where the `menu.lst` file described below resides:

- `e2fs_stage1_5`
- `reiserfs_stage1_5`
- `stage1`
- `stage2`
- `stage2_eltorito`

Again, the files for other platforms (LTSP, the System Rescue CD) must also be included within the directory which will contain the files for the boot CD-ROM [19]. Then, options must be created in the menu.lst file for all of the platforms that need to be accessed using this boot CD-ROM. Figure 3, contains sample entries for the menu.lst used in this implementation.

In Fig.3, as readers might have noticed, there is more than one entry for ROCKS. During the installation process, ROCKS labels the hard disk with characters referred to as LABELS in Fig. 3. Sometimes, these labels might differ even if it's the same version of ROCKS being installed on two identical computers. If this LABEL differs between nodes, a different entry is required in menu.lst for each. The options in the menu.lst are displayed as a menu by grub before loading any OS when booted from boot CD-ROM. The menu.lst file retrieved from different nodes can be compared for discrepancies. For this implementation, the boot CD-ROM contained more than just entries for the various Operating Systems contained on the hard drive. In order to avoid the requirement that multiple CD-ROMS be needed for booting as well as maintenance, the System Rescue CD ISO image was also placed on the CD-ROM. As space on the CD-ROM was available, DSL was also added, as indicated in the menu.lst file [21]. Additional distributions or bootable ISO image files could have been added, especially if a DVD were used instead.

The mkisofs command can be used to create a bootable ISO image that will use GRUB [18][20]. Once all of the ISO images are loaded onto the appropriate directories, along with the needed files for network booting LTSP and lastly all of the boot options are written onto the menu.lst, the following command will produce a single ISO image.

```
.
mkisofs -R \
        -b boot/grub/stage2_eltorito \
        -no-emul-boot \
        -boot-load-size 4 \
        -boot-info-table \
        -o CSI_BOOT.iso \
        iso_content
```

This command assumes that all of the relevant files and directories are placed in the local directory `iso_content`.

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```
title   Rocks 1
    root (hd0,0)
    kernel /boot/vmlinuz-2.6.9-22.EL ro root=LABEL=/1
    initrd /boot/initrd-2.6.9-22.EL.img

title   Rocks 2
    root (hd0,0)
    kernel /boot/vmlinuz-2.6.9-22.EL ro root=LABEL=/
    initrd /boot/initrd-2.6.9-22.EL.img

 title   Windows XP (/dev/hda1)
     rootnoverify (hd0,3)
     chainloader +1

 title   LTSP 100 megabit
     kernel  /etherboot/rtl8139.lilo

 # from isolinux.cfg sysrescuecd
 title   System Rescue Cd - 0.3.7
     kernel /systemrescueCD-boot/isolinux/rescuecd \
  root=/dev/ram0 init=/linuxrc vga=791 looptype=squashfs \
  loop=/sysrcd.dat dokeymap cdroot spash=silent
     initrd /systemrescueCD-boot/isolinux/rescuecd.igz

  # from dsl iso
  title   DSL 3.4
      kernel /dsl-boot/boot/isolinux/linux24 \
   ramdisk_size=100000 init=/etc/init lang=us \
   apm=power-off vga=791 nomce noapic quiet BOOT_IMAGE=knoppix
     initrd  /dsl-boot/boot/isolinux/minirt24.gz
```

Figure 3: Sample Entries for the GRUB menu.lst file

V. CONCLUSION

In this paper, we have described how to configure a lab to provide students the opportunity to work on various OS environments without incurring a huge cost. Moreover, by implementing a scalable cluster using ROCKS, students are provided with the opportunity to learn parallel programming as well as harness its supercomputing power for other research purposes without adding to the cost of laboratory maintenance. Moreover, the implementation described above is friendly to the general user because they never even become aware of other Operating Systems existing on the computer and the Boot CD acts as a key which secures the systems other than Windows. In addition to implementing the above mentioned Operating Systems, one can easily change their choice of Operating Systems and get computers that boot Operating Systems of their choice in the lab by following the procedure described in this paper.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Lessons from the E-Learning Experience in South Korea in Traditional Universities

Daeun Lee J.A. Redmond D. Dolan
Department of Computer Science
Trinity College, Dublin 2
Ireland
Contact: redmond@cs.tcd.ie

Abstract - **Lessons learned from a study of the e-Learning experience at traditional universities in South Korea are discussed and how e-Learning could be improved in the future is explored. Lecturers and learners show different attitudes in terms of their expectations of e-Learning.From this research, it is concluded that the current quality of e-Learning is not fully mature and problems remain with regard to socialization, standardization, student motivation, content re-use and the support of ubiquitous learning.**

I. INTRODUCTION

Information and Communications Technology (ICT) in education has removed the limitations of time and physical location. This has changed the perception of education. A growing number of organizations are now delivering training and education over the Internet, including colleges and university, corporations, military institutions, and even secondary schools. There are an estimated ten million courses online, and the U.S. alone reports about 700 e-Learning companies [1].

Purpose of the Research

This study aimed to identify the future direction of e-Learning in third level education systems by studying the example of South Korea. South Korea is a leader in the successful implementation of E-Learning. South Korea is number 1 in the world in terms of the broadband subscriber base size [2] and is number 5 in the world in e-Learning readiness through the creation of a world-class educational resources infrastructure [3]. 99.6% of students in Korea use ICT which places them at the top of international statistics on Internet usage (exceeded only by Denmark) and 86% of teachers use ICT for class [4], [5].

e-Learning is learning via the Internet, network, or standalone computer. e-Learning is essentially the network-enabled transfer of skills and knowledge [6], [7], [8]. E-learning is here to stay as the fast changing pace of technology, the shortening product development cycles, lack of skilled personnel, competitive global economy, the shift from the industrial to the knowledge era, the migration towards value chain integration and the extended enterprise [9], fuel its strategic importance and realization [9].

II. STATE OF e-LEARNING AT TERTIARY LEVEL IN SOUTH KOREA

A. State of e-Learning Support Centre

In 1998, the Korean government established the Virtual University Trial Project [10]. 162 universities are supported by 7 e-Learning support centres in 2007 and since 2003, 175 government-funded courses have been developed. E-Learning support centres serve to harmoniously and systematically support planning, development, and delivery of educational content needed for e-Learning, which will be shared by off-line universities located in the same region. The centre will be equipped with studio lecture rooms, a total support system for instruction, editing and broadcasting systems, and e-classrooms [11].

B. State of e-Learning Courses

According to [12], in order to improve the quality of education in universities, high quality of content is essential. The effectiveness of e-Learning depends on how the content can motivate learners and drive their study.

According to a KERIS study [13], which surveyed 52 universities in 2005, 78% of responding universities strategically developed their own contents and especially national universities and large scale (over 10,000 students) private universities. Its 2004 survey [4], to which 92 universities responded, shows that 73.9% of the universities developed e-Learning content in-house and 51.1% shared the content in a consortium. However, only 23.9% purchased commercial content and 8.7% collaborated and operated with commercial partners [12].

However, most traditional universities have suffered from a lack of support systems for content development. Instead, most individual lecturers have designed and developed their own content. This individual effort tends to simply transfer materials from off-line to on-line, raising copyright problems and ignoring instructional strategies [11].

III. STUDIES

A. Questionnaires Utilized

Student questionnaires were used to ask a) how satisfied the students were with their experience, b) the time effectiveness of the e-Learning class, c) the interaction between lecturer and students, d) technology preference, e) what difficulties they have found during e-Learning classes and f) further comment [14], [15].

There were multiple types of question and response modes to these questionnaires and students were asked to give multiple answers to particular questions.

Semi-structured interviews were taken focusing on the experience of e-lecturers in an informal way to get more in depth responses.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 216–222.
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mmeybodi@aut.ac.ir

B. The Sample Populations

One of the foci of the research was the Korea Virtual College (KVC) which was established in 1997 by 10 member universities from which 3 have seceded to leave 7 in 2007. Its purposes are improving the quality of education and interchanging high quality content between member universities by learner focused e-Learning. KVC opened 59 e-Learning subjects with 3520 places in the 1st semester of 2007. Another focus was the e-Learning course in Hyupsung University.

C. Two On-line Surveys

HyupSung University

An on-line survey was taken from HyupSung University, HwaSung, South Korea, which had 6 e-Learning classes with a total of 900 places in the 1st semester of 2007. The survey was placed on the university's eClass website and was customized for the university. Customized questions are highlighted in [14], [15].

KVC member universities

This survey was taken from the students of two KVC member universities' course: 'Introduction to Computer Games' and 'Basic Java Programming', and 46 answered.

D. The e-Lecturers

Six eLearning lecturers who had taught a class online in KVC member universities in recent years kindly agreed to be interviewed. Four lecturers taught in both the e-Learning courses in KVC and the on-campus class in the 1st semester of 2007 in KVC member universities. One lecturer is teaching an e-Learning class in KVC and teaching on-campus classes in a university that is not a member of the KVC consortium. Another lecturer gives on-campus classes in a KVC member university without any experience of on-line lecturing. This was deliberately done so as to explore how well an e-lecturer could cope without formal training.

A semi-structured interview took place in each lecturer's office and interviews were recorded with the interviewees' permission. The interview focused on the lecturer's experience in a) Content development and reuse, b) Student feedback and interaction, c) Student assessment, d) Any difficulties that lecturers have found, e) If suitable subjects had been found for e-Learning and f) Any improvements suggested by their experiences.

IV. THREE PERSPECTIVES ON THE SOUTH KOREAN e-LEARNING EXPERIENCE

The key features of e-Learning are looked at from three perspectives - those of Student, Lecturer and Administrator. These perspectives are informed by the results from the various studies discussed above.

A. Data Analyzis

Student questionnaires were the source of the quantitative data. The data came in different forms stored as Excel, MSWord, website comment and hard copy. Hard copy survey data were converted into electronic data. Other data from student questionnaires were stored electronically. All data were collected in Korean and have been translated into English during the data analyzis process. Translated data have been logged using Microsoft Excel 2000. For simplification in the analyzis, student major and student year were ignored. All multiple choice questions had their selective options and these options were analyzed.

Qualitative data came from the lecturer interviews and the open-ended questions of the student surveys. Analyzing the interview data used the following steps 1) reading an initial interview script that was written during interviews, 2) supplementing the initial script with the recorded interview, 3) categorizing the script into question groups and 4) translating the categorized interview into English. The data from the student survey were analyzed by a different process. First of all, data on the same question from 4 different sources of data collections (an offline survey, HyupSung University's survey and from 2 different e-Learning lecturers) were collected into a new file of Microsoft Excel 2000 and then translated into English. The second step was reading through all translated data and identified segments. After identifying the segments, all translated data were grouped by these segments.

B. Students Survey Plan

The details of the student survey, used in Hyupsung University and the survey used with the KVC consortium students, can be found in [14], [15].

C. Lecturer interviews

The lecturer interview was focused on the lecturer's experience and his/her view of e-Learning. All questions were open-ended and the same questions as were used in the student survey were used so that the issue could be seen from the lecturer's viewpoint. All lecturer interviews took place in March 2007 in South Korea. Six e-Learning lecturers kindly agreed to be interviewed. For the purpose of broadening out the data, lecturers were selected from various provinces, and from various sizes and types of universities.

Seoul Shi Area: 3 lecturers (Kwangwoon University, Hanyang University)

KyoungGi Do Province: 1 lecturer (HyupSung University)

KangWon Do Province: 1 lecturer (HylLim University)

Pusan Shi Area: 1 lecturer (KyungSung University)

D. Offline students survey

Two surveys of on-campus students in HanYang University and KyungSung University were taken during the travel period (March 2007). Due to a poor response to these two offline surveys, online surveys were designed and implemented.

E. On-line student surveys

KVC member Universities:

Two lecturers from KVC e-Learning courses kindly suggested and facilitated an on-line survey. They uploaded

mmeybodi@aut.ac.ir

survey papers to their e-Learning websites and got 11 and 35 responses out of 80 students.

HyupSung University:

The lecturer interviewed is a head of the e-Learning support centre in the university and had taught an on-line class on a KVC member university course. He uploaded a survey paper to the university e-Learning website as a diagnostic evaluation of their e-Learning system. The university ran six classes with 900 places in the first semester of 2007 and got 831 survey responses. Because the proposed survey was similar to their form for internal evaluation, the questionnaires were slightly modified to fit their system.

V. STUDIES' FINDINGS - STUDENT PERSPECTIVE

A. High percentage of computer ownership

The survey (Q.21) asked students to list all the equipment they have. 65.5% students have a desktop computer and 18.6% students have a laptop computer. Another 52.2% of students have mp3 players.

B. What e-Learning Mode do students prefer?

The student survey (Q.19) showed different preferences for e-Learning mode. 384 out of 897 42.8% students from HyupSung University and the KVC universities chose video type + Powerpoint/ lectures notes e-Learning content as their preferred mode. Audio (Presentation) + Powerpoint was chosen by 18.4%.

C. Ease of Communication

The survey (Q.13 Table 1) shows students have difficulties in communicating with the lecturer.

Table 1. Q. 13 How easy is communication with e-Lecturer?

Q. 13 How easy is communication with e-Lecturer?	HyupSung (n = 831)	KVC (n = 66)	Total (n = 897)
A. Difficult	24 (2.9%)	2 (3.0%)	26 (2.9%)
B. Not easy	142 (17.1%)	13 (19.7%)	155 (17.3%)
C. Moderate	469 (56.4%)	23 (34.8%)	492 (54.8%)
D. Easy	159 (19.1%)	17 (25.8%)	176 (19.6%)
E. Very easy	37 (2.3%)	11 (16.7%)	48 (5.4%)

55% of students said their communication with a lecturer was moderate and the most used method of communication was using a web forum (web bulletin board)(Q.14 Table 2).

Table 2. Q.14 Most useful method to communicate with the e-lecturer?

Q. 14 Most used method of communication with e-lecturer in Q13?	HyupSung (n = 831)	KVC (n = 66)	Total (n = 897)
A. Web forum/ bulletin board	385 (46.3%)	43 (65.1%)	428 (47.7%)
B. E-mail	184 (22.1%)	18 (27.3%)	202 (22.5%)
C. Phone	53 (6.4%)	2 (3.0%)	55 (6.1%)
D. Visit	24 (2.9%)	1 (1.5%)	25 (2.8%)
E. Internet messenger	10 (1.2%)	1 (1.5%)	11 (1.2%)
F. Other (Haven't tried)	175 (21.1%)	1 (1.5%)	176 (19.6%)

The reason they gave for difficulties in communication are given in Table 3 (Q.15). Students were asked to give as many opinions as they could give. This question is not analyzed in a quantitative way as it was an open-ended question. A similar result was seen in the question asking about the communication with other students who attended the same e-Learning class.

Table 3. Q. 15 If the communication with the e-lecturer was not easy, what was the reason? Some individual responses:

Q. 15 If the communication with a lecturer is not easy, why?
Student cannot always be on-line
Students cannot query immediately when they have question
Student cannot communicate face-to-face
Student does not know the lecturer well
The inconvenience of sending email
Student cannot get a response in real time
Student found that the lecturer did not respond
The communication medium not as convenient as a physical meeting
Hard to get the e-lecturer by phone
There is no easy way to contact the e-Lecturer
Cannot use web forum
Time constraints
Afraid of showing ignorance on-line
Students are too shy to talk to e-Lecturer
Feel it would be an uncomfortable experience
Lack of familiarity with the e-Lecturer
Communications are only off-line
Response lag
Not face-to-face
Lack of interaction
Because it's a non-human system
The medium is not friendly or powerful enough for the query
Privacy issue of using the web forum
Web forum and phone are not effective enough
Typing makes it difficult

Student survey question 33 asked students what they found to be the weakest facet or disadvantage of e-Learning. Students responded that e-Learning gives them too much responsibility for studying and without adequate motivation, it is difficult to expect them to be able to study effectively.

Some typical student responses to this open-ended question are:

"Low self-motivation"

"There is nobody checking whether I actually watched the lecture or not. So I rarely watch the full lecture. I am getting lazy"

"It requires self-control. Without this, e-Learning is useless."

"It gives too much freedom and requests a responsibility that is difficult."

"If a student is not self-motivated, e-Learning is not more than getting the credits. Also nothing is being learned"

"If the motivation for the learning is low, it is difficult to follow lectures. It is the same in the face-to-face lecture but e-Learning is more difficult."

"Without an ideal system that leads students to be involved and to be self-directed e-Learning delivers only surface learning and it is difficult to study in depth."

"There is no sense of the real. Without motivation, studying is impossible."

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"I do not concentrate on the lecture. Most students may do so. It is only for attendance checking. I doubt if any actually watch the lecture clip."
"It is on-line and unobserved and the idea just to fill the required time for the credits comes to me quite often. I think I have never actually watched lecture files."

VI. STUDIES' FINDINGS - LECTURER PERSPECTIVE

A. Available Courses:

Lecturers see the necessity for e-Learning and its usefulness. Especially since e-Learning makes available to students, courses in other universities that are not available in their home university. A subject 'Introduction to Computer Games' that was a KVC e-Learning class in the 1st semester 2007 was available to students in universities that were members of the KVC consortium.

B. Time Usability

Time usability is another big advantage that lecturers see. An on-campus lecture must be done in scheduled time but an e-Learning class is accessible whenever students are ready as long as the lecturer has created the required content.

C. e-Learning is more intensive

Also lecturers could do more intensive work in an e-Learning class than they could do in on-campus lectures since the lecturers do not need to check students who were accessing the lecture file, since the e-Learning system checks it, and there is no public holiday for an e-Learning class.

For instance, one interviewed lecturer (Lecturer 2) taught 3 hours in an on-campus class per week and 1 hour in an on-line class per week for the same amount of content. Another lecturer (Lecturer 3) found that a 1-hour on-line lecture could cover more topics and content amount than a 3-hour on-campus lecture. However there is no way yet of evaluating if the same amount of learning occurred in both situations.

D. e-Learning Boredom

Lecturer 3 found from his experience that students get bored quickly and easily while they are watching an e-Learning lecture. In attempting to reduce the boredom, he now creates a lecture in three 20-minute lecture files.

E. Lack of e-Lecturer Motivation

In the 1st semester 2007, KVC had 59 e-Learning classes from 7 universities. All KVC member universities have multiple departments and majors. For example, KyungSung University (a Regional Support University) has over 300 lecturers, 6 colleges with only 6 lecturers who gave KVC e-Learning classes and another 4 lecturers who gave a class in the KyoungNam region e-Learning support centre in the 1st semester of 2007 (i.e. 10 e-Lecturers out of 300).

F. How to better motivate eLearning Students?

The lecturer can find whether students in his (her) face-to-face class understand or follow his lecture by reading students' faces and following their eyes when doing an on-campus lecture (Lecturer 1). However, this is not possible in an e-Learning class. So lecturers have their own strategies to make sure their students follow the lecture.

Lecturer 6 had a Java programming class on a KVC monitor web bulletin board where his students could freely write and read articles. He also informed them that he would monitor their use of the web bulletin board as part of an evaluation method for the course. This worked well.

Another lecturer (Lecturer 4) made two different copies of lecture notes. One was for himself and the other was for his students with deliberate blank spaces where students in the course could insert words while they were taking an e-Learning lecture. The filled-in lecture notes had to be submitted to the lecturer. It became a part of evaluation data at the end of the semester.

G. e-Learning Mode Type favoured by eLecturers

Five lecturers interviewed have given e-Learning classes in the 1st semester of 2007 and their contents were text-based given as a slide show, such as MS PowerPoint with recorded voice. This was called the Presentation (Audio) Style above (as distinct from a video of the lecture). A sample screen of an e-Learning class on KVC is given at http://www.kvc.ac.kr/BestContent/default/main.asp.

Lecturers preferred the voice recorded on presentation (audio) type content rather than the video clip type of content which students preferred (see Table 1). All lecturers could use a recording studio on the campus and staff from the e-Learning support centre could record. However, lecturers were not professionally trained for video recorded lectures and therefore did not particularly like making a video. Using the video equipment in the Resource Centre was bureaucratic and time-wasting due to competition for scarce resources. Lecturer 5, due to time-consuming and time-wasting experiences, now records his lectures using a webcam on his desktop computer. He records mouse motion using a screen capturing application such as Camtasia (http://www.techsmith.com/camtasia.asp).

H. Difficulty in assessment of student e-Learning

The student survey showed that students think the weakest side of e-Learning is the fact that the student can do something else while he/she plays the lecture files online. Then the administration system of the e-Learning system will mark that the student has attended the lecture, and therefore this contributes to the eventual credit for this course for this student.

From the lecturer's viewpoint there are not many effective methods of evaluating a student's learning progress:
"As there are no measurements for the learning achievements of students, the assessment of each student at the end of the semester is the hardest part" (Lecturer 3).

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For better assessment, the interviewed lecturers tend to give students homework more often than they give students in offline classes. For instance, the evaluation weights for the Java Programming class at KVC were: the online final exam (40%), homework (20%), which was given every week, and attendance (40%) by monitoring of the web forum.

Another lecturer commented regarding the online exam:
"I have heard from my students that 3 or 4 friends are sitting with books in the Internet café together and helping the student who is taking an online exam by finding answers from the book. There is no specific physical location for the exam so that it could be supervised".

VII. STUDIES' FINDINGS - ADMINISTRATION PERSPECTIVE

A. Non-Reuse of Content

The Universities encourage the lecturers to do e-Learning classes with financial support. KwangWoon University gives 2,000,000 Won ($2,150) to a lecturer when he/she starts an e-Learning course with a new subject. If the lecturer gives the same course in another semester the amount of financial support becomes 1,000,000 Won ($1,075). The third time the lecturer gives the same subject with the same content it is 500,000 Won ($536) and for the fourth time there is no financial support. The content is the property of the e-lecturer so obviously if he decides not to re-use the course content, it is obviously not available to the university population.

None of five lecturers from four different universities used their content again after deciding not to continue their courses with previously created content after the financial support period ended.

B. How to manage the quality of e-Learning content?

"How to encourage lecturers to be keen on the quality of e-Learning content should be researched. By financial support or by the culture that if lecturers are seeing other lecturers creating much better quality content and students prefer that content, lecturers will be more competitive for quality" (Lecturer 4). Incentive and reward schemes for e-Lecturers are lacking.

C. Why are cultural (non-major-related) subjects popular for e-Learning?

The KVC consortium universities gave 59 courses in first semester (starting March 2007). These can be broken down into the following areas (Table 4):

Table 4 KVC e-Learning Course Breakdown 2007

Course Area	**Number of Courses**	**%**
Cultural	20	33.9
Liberal Arts	15	25.4
Science & Engineering	17	28.8
Business Administration	4	6.8
Medicine & Nursing	3	5.1
Total	59	100

Students have to get certain credits from general or cultural subjects (non-major subjects) and from their major-related subjects to graduate. All credits that students have gained from KVC e-Learning classes are treated as non-major subject credits. Lecturers point out the difficulty of e-Learning subjects which require previous courses as building blocks for a particular subject. This is a serious problem due to a lack of agreement on a standard curriculum. Stand-alone subjects are not usually a problem. Lecturers point out the difficulty of e-Learning subjects which require previous courses as building blocks for a particular subject. This is a serious problem due to a lack of agreement on a standard curriculum. Major subjects present difficulties as e-Learning topics since previous courses are needed as building blocks. There is no standard curriculum and little agreement on building block courses.

"Most major subjects tend to be very theoretical especially the mandatory ones. If anyone tries to do online classes with these subjects, the lecture notes will be full of text and they will be boring. Also it is more efficient to use a textbook for the first or the second year students rather than an e-Learning course" (Lecturer 1).

D. Does government support work?

The lecturers interviewed commented that e-Lecturers get few, if any, benefits. There are few government incentives for e-Learning lecturers to produce and/or reuse content other than those discussed above. There are severe limitations to Government support for most universities. Most support goes to the designated Regional Support Universities.

"Government support is focused on hardware such as building a recording studio and buying servers for the e-Learning system. It does not help students or lecturers much" (Lecturer 2)

"The government supports particular universities and so if any other university is willing to start an e-Learning system, it finds it hard to get any support at government level." (Lecturer 5)

"The government supports the central university in the region only and ask other universities to get support through that central university. It is not helpful in reality" (Lecturer 4).

E, Socialization in e-Learning

Online learning has the characteristic of being aimed at the individual alone. The results of the student questionnaires show that the students have found there is a lack of interactivity with other students and also with lecturers and they do not like this. Particularly students have felt that contacting the lecturer or other students is not easy when they do not know him/her well. From this result,

mmeybodi@aut.ac.ir

socialization in e-Learning is required in order to improve the current e-Learning system [16].

F. Re-use of e-Learning content

All educational organizations cannot afford to develop all the needed e-Learning content and e-Learning support systems. In order to maximize the reuse of e-Learning content, the following ideas are suggested.

G. Need for standardization

In the context of e-learning technology, standards are generally developed for use in systems design and implementation for the purposes of ensuring interoperability, portability and reusability [17]. Standardization of e-Learning content will enhance the re-use of the e-Learning.

VIII. CONCLUSIONS

- e-Learning in the third level education is not fully mature in terms of student and lecturer acceptance and university operation.
- there is little benefit for e-Lecturers to motivate themselves to do e-Learning teaching.
- improving the communication and interaction between student and lecturer and between students is urgent in an e-learning situation.
- the government needs to improve its policy of supporting e-Learning iteratively.
- research in managing quality and evaluation of e-Learning content is required to enhance e-Learning.
- emerging technologies may soon make learning opportunities ubiquitous.
- students in e-Learning classes require to be self-directed.
- In South Korea a factor in the acceptance and effective use of e-Learning is the hangover effect on students of having to struggle hard with little sleep in their final high school year to get into university. The consequence of this struggle is a severe emphasis on grades and credits and little learning for learning's sake.
- It is noticeable that younger students in their 20's are not enamoured of e-Learning. Those that make effective use of e-Learning are older students. This was also noticed in [18] and commented upon in [19].

IX. SUGGESTIONS FOR FUTURE WORK

Areas for future work are suggested by this research are:

- Study how the international research in the e-Learning standardization is progressing and how it is practised. The IEEE and ISO/IEC are working on e-Learning standardization. It is important how standardization may be applied to the education and training sectors.
- Study how to motivate lecturers to do e-Learning classes. Currently many universities are using financial support for motivation as well as improving the quality of e-Learning. Can the financial support motivate lecturers to do e-Learning classes?
- Study how to motivate students to get involved in e-Learning lectures. From the research, Korean students are not much involved in e-Learning in terms of giving feedback and being socialized.

There is no doubt that e-Learning is here to stay in one form or another both in universities and in industry. The challenge is how to make the most effective use of it so that students really want to use it. Education in general is expensive if it is to be effective. It is important to look beyond e-Learning as a cheap, mass-education method. Instead we should work to its strengths and minimise its weaknesses.

ACKNOWLEDGEMENTS

We are much indebted to the following South Korean academics for their help and support:

Professors YongHo Song (HanYang University), SangHun Lee (KwangWoon University), KangSung Lee (KwangWoon University), SungKi Kim (HyupSung University), KiDuk Kwon (Hallym University), HeeJae Yang (KyungSung University).

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mmeybodi@aut.ac.ir

Some Innovations for Keeping an E-Learning System Alive

J. López-Cuadrado[1], T. A. Pérez[1], S. Sanz-Santamaria[2], A. J. Armendariz[1], J. Gutiérrez[1], J. Á. Vadillo[1]
[1]Dept. of Computer Languages and Systems of the University of The Basque Country (UPV-EHU)
Paseo Manuel de Lardizabal, 1
Campus de Ibaeta, Donostia – San Sebastián 20018 SPAIN
[2]Dept. of Mathematics and Computers Engineering of the Public University of Navarre
Edificio departamental Las Encinas
Campus de Arrosadía, Pamplona 31006 SPAIN

***Abstract*- Keeping an e-learning system alive consists not only in developing and installing it, but also in maintaining the system updated, improving its features and adding new ones. Hezinet is a commercial e-learning system for Basque language learning that is being used since 2000 in more than 60 Basque-adult schools. In this period, although the good results achieved, authors have realized the necessity of some improvements and new features. This paper introduces three new components of Hezinet as a way to present some key issues in the development of a successful e-learning tool: a computer adaptive admission test generator, an on-line calibration supporting component, and an item/test authoring tool.**

I. INTRODUCTION

As the demand of new technologies and systems to support education grows, Hezinet arises as a Learning Management System with a double purpose: on the one hand, it solves the problem to all those students who cannot attend classes regularly, and, on the other hand, it works as a complementary and supporting tool to reinforce what it has been explained in the classroom [1]. Besides, its adaptive characteristics, which are adequate for both constructive and instructive learning, and the usability and friendliness of the system, allow Hezinet to be used in most of the *euskaltegis* (Basque adult schools) for Basque language learning.

During seven years of operation of this system with real users and having the experience and observation of its use, the authors have been working on how to improve it, not only from the student perspective, but also from the content developer's point of view. This improvement is focused on user-interface issues, and also on the inclusion of new tools that will help the user during the interaction, as they add further features too. At the moment the work is centered on several components that are being integrated within the system. Hezinet will soon include a computerized adaptive admission test generator, an item calibration supporting tool and an item/test generation component.

The *computer adaptive admission test generator* (GenTAI) [2] is already operational both as an independent assessment component and as an integrated tool. It performs adaptive tests to decide the initial ability of new students by using less items than traditional paper and pencil tests, but providing the same level of reliability. These Computerized Adaptive Tests (CATs) [3] are based on a mathematical model stated by the Item Response Theory (IRT). The inclusion of this component reduces the number of items that have to be administered to every new student due to the nature of CATs. This kind of test emulates the intelligent behavior of human evaluators, since they dynamically apply the most appropriate items depending on the previous answers given by the examinee. Actually, a CAT always presents the examinee items that are very close to his or her estimated ability level, so every administered item gives useful information to determine the student's skills.

Applying IRT to the development of CATs brings some inconveniences too. The most important one is that the items have to be calibrated; in other words, some parameters of the IRT model, such as the difficulty of every item, must be estimated. The tasks required to complete the calibration process are not complicated but time and resource-consuming [4]. The most typical (and most resource demanding) way to achieve a calibration consists in applying the item bank to a large sample of examinees to statistically estimate the item parameters [5], but it could be done (in decreasing order of resources they demand) by several experts, one expert or even oneself.

The *item calibration supporting component* (CALLIE) will help content developers to build new calibrated item banks to feed both Hezinet and the item/test generation component. The calibration helping tool will point out which conditions are necessary to estimate the parameters, and it will help content developers (which might not know how the calibration is performed) through the different steps that should be followed. The idea is that the system will automatically offer support over the different stages of the calibration process.

Finally, the *item/test generation component* (ADISTI) will improve Hezinet with two main contributions: the use of e-learning standards for exchange purposes and the application of multiple types of items in the evaluation process with the aim of obtaining complete assessments. By means of this component, teachers can create items and tests, including interactive activities and multimedia items, just by filling in a simple form. All generated items and tests are stored according to the standard specification IMS QTI [6]. This process is automatic and completely transparent to the user. The tool also includes features to import and export items and tests, and allows their modification. Moreover, it is planned to add an on-line assistant that will help content developers while designing items according to pedagogical techniques.

Next section will present Hezinet in more detail, while sections 3 to 5 will discuss the cited new elements: the computerized adaptive admission test generator, the item calibration supporting tool, and respectively, the item/test generation component. Finally, section 6 will present conclusions and future work..

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 223–228.
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mmeybodi@aut.ac.ir

II. HEZINET

Hezinet [1] is a pioneering commercial system for distance language learning which is nowadays being used in more than 50 Spanish and 14 South American adult Basque-schools. It is a mixture of an Adaptive Hypermedia System (AHS) and an Intelligent Tutoring System (ITS), so it takes advantage of the positive aspects of each archetype and rectifies their inconveniences. Concretely, hypermedia features offer flexibility when managing the navigation to didactical contents, while the tutoring system controls users and performs evaluations of the navigation to adapt the system's behavior. This symbiosis avoids the ITS to control the instruction too strictly, so a more autonomous learning process is obtained. Hezinet also benefits from the inclusion of different audio-visual media which are used by the AHS to present the contents to the student.

The AHS-ITS integration can also be seen as a combination of constructive and instructive elements. The formers let students find the solution to problems in an independent way, that is, without presenting them the solution directly. Actually, Hezinet bases its constructive features on delegating the navigation control to the students by means of the hypermedia, which offer them many different ways to establish the path to follow through the knowledge-web. On the other hand, instructive elements provide the system conscience about the tasks a student is being performing and, if it is necessary, they execute some control over the learning process.

Hezinet manages its pedagogical contents by dividing them into 5 courses, each corresponding to two of the different levels determined by the Basque official institutions. Also, every course is structured in layers, which are placed in order so that their difficulty increases progressively. In the same way, a layer is divided into about 10 sets of activities, which are called sessions, lasting each one about one hour.

The sessions in a layer are classified in three categories. First of all, there are predefined sessions, which are very elaborate and are shared by all students. Then, there are review sessions, whose presence is particular to one concrete student and means that he or she has not acquired adequately some concepts. So, they are created automatically to review these concepts. Finally, there are teacher-defined sessions, which also correspond only to one particular student and are created on the fly by human teachers to make her or him review certain aspects of the language. Teacher-defined sessions are usually generated as a consequence of some kind of interaction with the student, i.e. after an interview.

Sessions are the nodes of the hyperspace managed by Hezinet and they represent independent pedagogical scenarios [7]. Independence is crucial when talking about language learning because the progression through the hyperspace is not imposed. Every session has three parts, in the following order: at the start a multimedia document is shown to introduce the background where the whole session will take place; then, the student must complete the set of independent activities that compose the pedagogical scenario; and, finally, a section where student's knowledge acquisition is evaluated is reached. At this point the user has to solve some activities, which are taken from the same bank used for learning, with the difference that there is no complementary help available during the evaluation.

Hezinet contains a collection of activities linked to each content. Contents are the smallest pedagogical units that are taught. Some of these contents work as a key in relation to others, that is, they cannot be shown until others, which are considered to be prerequisites, are mastered. Actually, activities are the most important pedagogical components of Hezinet, since they attract students' attention and provoke them to work with their contents. The system creates scenarios where the student has to search for the correct response within the supplementary support material integrated in the system, such as help pages, a hyperized book of grammar, an on-line dictionary, and messaging tools. The authors consider that a correct resolution for an activity implies that knowledge has been transferred, while the opposite means that the student should check the procedure followed to solve the problem.

Hezinet includes up to 20 different types of activities, such as highlight mistakes in a text, multiple-choice exercises, true/false exercises, free answer exercises, ordering exercises, and compositions or essays. Many multimedia resources have been used to develop the set of 10231 activities that Hezinet contains, including 364 videos (4.99 Gb in MPEG format), 703 audio files (1.5 Gb in MP3·format), and 72 interactive films (500 MB in DCR format).

The system distinguishes three main user profiles: administrator, teacher and student. The administrator is the user responsible for inscribing students and teachers. Teachers have certain functions available for each of their students: they can for instance add or remove contents from a student's profile as they monitor the students' learning processes. The main users of Hezinet are the students, since the last objective of the system is to allow them to acquire a certain level of knowledge of the Basque language. Once the student has logged on in the system, he or she will be driven to the point where the system was left the last time. At this point the student can continue the learning process in the way explained before.

The results of Hezinet's users in the Basque Government official exams have proved the system to be very helpful in language learning, but at the moment the figure of the human teacher is still essential. The technology does not permit to develop a language learning system without a human teacher to advise students and to conduct the oral sessions. However, this is not necessarily applicable to some concrete but complex tasks, such as taking decisions about the initial layer and course of new students. Actually, as next section will describe, Hezinet includes an assessment component that makes use of computerized adaptive testing to automatically place new students in the most appropriate point to start their learning processes.

III. GENTAI: ASSESSMENT FOR NEW STUDENTS

Although Hezinet encourages students to be the supervisors of their learning process, it includes other elements to assess the instruction. Actually, following the techniques inherited from the ITSs, the system automatically monitors and controls the knowledge acquisition by using tests. Hezinet works with 3 types of tests for this purpose [1]: session tests, containing activities about the contents that have been recently studied in a session; layer tests, including items that cover the knowledge level of the current layer in the course; and course tests, with

mmeybodi@aut.ac.ir

exercises about the key-contents of the current course, that is, those that pedagogues have considered essential to succeed the course, and therefore to pass to the next one.

Session, layer and course tests present their adaptation features in terms of the results obtained by the user in previous tests. It is a fact that whenever a stage (that is, a session, a layer or a course) is finished, students have to complete a test: if they pass it, they will be able to start the next learning stage; if not, a new session about the same contents treated during the current stage will be automatically generated. Therefore, items included in already passed tests can be taken into account when a new one is being prepared, for instance, to avoid continuously asking about contents that previous results indicate that are well-known by the student.

But another type of assessment is also needed in an educational system like Hezinet: the admission test. This kind of examination includes representative items that manage contents of the whole learning scope, since the purpose in this case is to deduce the ability level of new students in order to determine their initial course and layer.

In the first versions of Hezinet tutors guessed which was the initial student ability, and determined the starting level to work with the system. A set of 10 tests, each of them with a different difficulty level, was available for the teacher, who, after having a personal interview with the student, decided which of these tests would be administered. The process was very rudimentary, since in some cases (i.e. when the correct responses ratio was excessively high or low) the new student had to complete several tests. Although this system would be appropriate for novice students, it surely was not for latter level learners. For instance, if one optimistically considers that a student uses 30 seconds to answer an item, the most proficient users should spend more than two hours to complete the admission tests in the worst case.

For this reason, we have developed a new type of admission test that reduces, from about 120 to only 30 or 40, the number of items to be administered to the student, without losing accuracy and reliability. This trial is based on computerized adaptive testing, which offers many advantages to those learning management systems that incorporate an assessment component: concretely, an increase of the security, a reduction of the time needed to pass the test and more precise estimations about the student's real ability. CATs emulate the intelligent behavior of human evaluators, since they dynamically select and administer the most appropriate items depending on the previous answers given by the examinee. After an initial trait level is assigned to the student, he or she must answer the set of items that dynamically are added to the test. During this period the ability of the student is progressively refined and subsequent items are selected to fit this level of aptitude. Thus, if a student, as expected, solves incorrectly an activity which is estimated to be difficult for the current ability estimate, then next item will probably be a little bit easier, so that the exact ability status will be more precisely estimated.

To identify the proper item from the item bank, the CAT algorithm makes use of some psychometric characteristics of the items, i.e. the parameters of an underlying model that is stated by the IRT [8]. This theory provides very powerful techniques to carry out the evaluation, particularly when using CATs, but it imposes significant constraints. The most important one is that the item bank for the admission tests has to be calibrated, which means that some parameters of the evaluation items, such as their difficulty, must be statistically estimated to fit the requirements of the IRT model being used (in this context, the 3-parameter logistic one [9]). In order to collect accurate estimations for these parameters, the theory required the authors to collect at least 500 responses per item. A web-based supporting tool was developed for this purpose [10], which not only allowed the researches to manage and organize the administrations needed during the item bank calibration, but also stated the basis for the development of the item bank calibration component.

In a future development stage, it is planned to enlarge the bank by the inclusion of new assessment items. They will also be calibrated following the 3-parameter logistic IRT model, but the calibration for these new items is expected to be performed following an easier procedure that will take advantage of the previously calibrated items. This method, know as on-line calibration, consists in administering to a large population a test, which is composed by some new (uncalibrated) items and some anchor items that are taken from the calibrated item bank. These data can be used by CALLIE, the calibration component to reduce the amount of data to be gathered.

IV. CALLIE: THE CALIBRATION COMPONENT

Although Hezinet is prepared to work even with no information about the items, their effectiveness increases when the system is provided with some data about them. We have considered the relationships with concepts covered by the item and the influence they have on students, as psychometrics suggests using its difficulty, discrimination and pseudoguessing. The process of relating an item with its characteristics is called calibration. When doing it formally, it becomes a complex task that needs of knowledge about some statistical processes that a usual content author might not be aware of.

The utility of CALLIE acquires relevance when authors want to calibrate their item banks. It is a tool specifically developed for courseware developers without specific knowledge in either psychometrics or statistics. Its main goal is to let them be able to calibrate any set of items. CALLIE deals with three calibration modes: manual, through experts and psychometric.

Manual calibration is the easiest way to estimate item parameters. The author simply decides their values and lets the system know about them. It is recommended to include only the difficulty in IRT terms when using this method. For that reason, CALLIE provides different ways to carry out the calibration; for example, courseware developers can define items' difficulty using several scales, such as percentages or the [0,10] interval. In any case, authors can always include difficulty, pseudoguessing and discrimination parameters as well.

Calibration made by experts is used when authoring and calibration processes are done using separate roles. In this case, one or more experts are inquired about their estimation of the parameters for the items. At the end, several algorithms can be applied to estimate the values of the parameters that will be assigned to an item, and at the same time to determine which items are valid. One of them is the maximum

mmeybodi@aut.ac.ir

consensus algorithm, which, after gathering the opinions of a set of experts, shows them the results for those items with consensus, to finally let them discuss and change their minds when there is no clear agreement.

Psychometric calibration is based on statistical methods. The main requisite is that information about behavior of every item has to be gathered. This fact implies the need of multiple administrations of each item in the bank. The more parameters one wants to estimate, the more administrations he or she will need. For instance, as already discussed, the authors have used a sample of more than 500 administrations per item to calibrate an item bank following the 3-parameter logistic model.

The simplest way to get all these administrations is to present all items to as many individuals as needed. Better, since it is possible that some will not be valid, it is recommended to slightly exceed that number. Of course, the method should change when the number of items grows, because tests with more than a particular quantity of items become hard to be completed by one person. The limit depends on the time needed to answer the items. In this context, experts consider that administering tests longer than one hour can include some external factors into the responses given, such as fatigue, which are not adequate for calibration purposes. That means that if one considers that one minute per item will be needed, the limit could be on approximately 60 items per test. When the amount of items to be calibrated is big enough, it becomes necessary to administer just a part of the items. For instance, if the bank contains 200 items, it is very likely that a 200-item test would be too long. Thus the author should divide the test, for instance, into four 50-items long subtests.

At this point, the following problem arises: since not all the individuals will give responses to all items, one has to find a way to establish correlation in the measures obtained for every subtest. This is accomplished by sharing some items (called anchor items) among all subtests. For instance, among the 250 items of the bank for the Hezinet admission test, 22 were shared by the defined 6 subtests, and, thus, each subtest was 60 items long. Needless to say that the more subtests one has, the more administrations of tests he or she will require (and also, the shorter the subtest will be). CALLIE is able to divide the bank into several N-items long subtests including M anchor items each. Although the system will suggest N and M, the user can modify their value. Moreover, the supporting tool gives the user the chance to print the forms in order to perform traditional paper and pencil test form administrations, but it can also prepare the infrastructure needed to automatically do the administration using computers instead. Of course, using the former has the disadvantage that after the administration, the user has to feed the system by transcribing the results. The latter, conversely, gathers those data automatically, and controls not only the number of times each subtest is administered, but also some other security controls, such as avoiding (if possible) dispatching the same test at the same moment. Besides, one can get a report of how much work is either done or needed. Also, the user will be able to revise data of a concrete administration of a test and mark it as accepted or rejected, so gathered data will, or respectively will not, be used during the item parameter estimation process. When the system finishes the calibration, it will let the user know.

From the results of the previous process, the system will be able to show some problematic items; for example, those that seem to be difficult to people with higher skills and, at the same time, seem relatively easy for those with lower skills. In any case, the system will provide a report including the detected anomalies, so the user will be responsible for, following her or his criteria, maintaining (validate) or deleting (invalidate) those items.

Finally, CALLIE will estimate and equate the item parameters in a transparent way for the user.

V. ADISTI: THE ITEM/TEST GENERATION COMPONENT

Since we found very important maintaining up to date the item bank, we created ADISTI [11] as a component for generating items and storing them. This tool made possible the creation of several types of items, such as multiple-choice, fill in blanks, ordering or correspondences, among others. Once the item was designed, it was stored in an item bank. All the items developed with ADISTI follow the IMS QTI specification. The tool can work both as an independent module for generating items, and integrated within an e-learning management system.

Taking ADISTI as basis, we are now working on the development of a new item and test generation component. Regarding the definition of items, this new component makes possible to design completely items from scratch or import them. Of course, the modification or deletion of items is also allowed.

Although multiple choice items are mostly used for evaluation, there are many other types that could be applied in e-learning assessment, which provide diversity and use the multiple advantages of multimedia. ADISTI not only covers well-known item types such as multiple choice, multiple response, matching, association (1:1), true/false or short answer, but it also pays special attention to other types like fill in blanks (with variants such as graphics), ordering, union (1:N), essays, projects, case studies or simulations. Moreover, in the near future, the component will offer even more types like hot-text, hotspots, select point, object positioning and slicing.

Besides managing items, the component is also prepared for managing tests. It works with static tests that will be stored in the test repository, which can either include specifically designed items or take them directly from the item bank. It will also create dynamic tests where items are taken on the fly from the item bank following a specific algorithm.

The last improvement of the new module concerns pedagogy. In this sense, there are two research lines opened: one about pedagogical techniques and researches that could explain which type of item develops better a concrete skill, ability or cognitive level, and other about the relationship between items and the pedagogical domain. Regarding the former, the aim is that the component could offer the opportunity of designing quality items without being expert pedagogues. To achieve this goal, the item/test generation component will include an on-line guide to help teachers decide which type of item is better for achieving a particular skill or how to design items that work the different levels of Bloom's taxonomy. For that reason, we are in contact with expert pedagogues and teachers to collect their knowledge and

mmeybodi@aut.ac.ir

apply it to the component. With respect to the latter, we are working on taking advantage of the pedagogical domain where an item is applied. Most available e-learning systems relate each item only with a concept, but we think that it would be very interesting to go further on and relate items with composite concepts and also with the relationships between concepts. The finishing touch, in this way, will specify which cognitive level of the Bloom's taxonomy works each item.

VI. Conclusions

The key issue for a successful e-learning system consists not only in having a good product, but also in offering its users new features regularly and keeping on innovating. Hezinet is a paradigm. It started as a simple e-learning system and, step by step, it has become a learning tool for a wide audience. Actually, the system has been configured to be used in several scenarios. The first version of the system appeared in 1999 as an e-learning tool that worked on demand to complement instructional lessons. Any person buying it could complement her or his Basque lessons through the Internet. The license entitled the user to receive one CD with multimedia resources and one account in the central server. From that moment on, the student could start the first course interacting with the program in the server. Once the student had passed the first course, he or she received a second CD covering the second course and so on.

The second use of Hezinet encourages self-learning. It was first implemented in 2000 within the Zibergelas (Cyberclassrooms in Basque), which are situated in cultural centers, usually supported by public organizations, such as city libraries, Basque houses and town halls. These special classrooms incorporate not only Hezinet, but also the multimedia digital library CiberBiblio [12] and the electronic paper and journal web server Kiosk@. These three systems established a learning system known as HEUSKLEARNING [13].

Finally, the third version of the system, which was created in 2002 with the commercial name of BOGA, also supports self-learning, but it is not necessarily linked to a physical place or learning institution.

Lately, we have centered our effort in including new features to Hezinet. The strategy has been to adapt it to new standards and also to create new components to be added to Hezinet or any other LMS. We have adapted the system to a learning standard using IMS QTI for items. We also have developed a computerized adaptive admission test generator, a supporting tool for item calibration and an item/test generation component.

Although Hezinet did not include standards at the beginning, nowadays the new component for item and test generation addresses the features of importing and exporting pedagogical material. This enables the possibility of interchanging educational documents, such as exercises, tests or contents and lets the user change the supporting e-learning management system without losing the courses.

The CAT generator creates admission tests to decide which level is the most appropriate for a new user of the system. This new component will reduce the number of items needed to take such a decision, without losing accuracy and reducing, thus, the time for placing students in their corresponding level. But it has arose a new need: items must be calibrated.

The need of item calibration has motivated the developing of a supporting tool to ease such a task. Although calibration is composed of simple tasks (basically test administration and some statistical operations), the amount of items and the number of administrations to be done could make the process unmanageable. The item calibration component will guide the system administrator through this process and offer alternatives to be chosen. The tool will be used as a simple checklist with tasks to be done or as a system to do those tasks automatically.

The accommodation to new standards has made to redefine the item design component to work also with the QTI standard. Also, we have widened its scope to cover new items with different media.

All the functionality has been included in an extensible architecture for the e-learning system: ELSA [14]. Furthermore, whenever a task can be accomplished using several approaches, the design has been done so that even when we only implement one of them, it will be easy to add another approach without changing the design. For example, one can find several ways to compile tests, to estimate student abilities, and so on.

We plan to add new helping tools to guide the process of course design. Our goal is to let the course designer to establish relationships between items and concepts, and also between items and events within Bloom's taxonomy.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Applying a Methodology for Educating Students with Special Needs: A Case Study

J. L. Fuertes[1], Á. L. González[1], G. Mariscal[2], C. Ruiz[2]
[1] Facultad de Informática, Universidad Politécnica de Madrid
Campus de Montegancedo. 28660 - Boadilla del Monte, Madrid – Spain
[2] SETIAM – CETTICO, Campus de Montegancedo. 28660 - Boadilla del Monte, Madrid – Spain
[1]{jfuertes,agonzalez}@fi.upm.es
[2]{gmariscal, cruiz}@cettico.fi.upm.es

***Abstract*- The introduction of innovative educational technologies opens up new ways of interacting with students. We propose to exploit this potential to help in the education of children with special needs. We analyze the state of the art of tools supporting the teaching process, focusing on the omissions of existing research. We propose a new framework to help throughout the whole teaching process and describe its application to *Proyecto Aprender* (Learn Project), an educational resource targeting children with learning difficulties. Finally, we outline some conclusions and current/future research lines.**

I. Introduction

Teaching pupils with SEN (Special Educational Needs) is a complex task. It involves implementing a teaching process and providing access to materials suited to pupils' skills. This depends on each individual's educational needs. For each pupil, this entails establishing a special-purpose and individualized programme of competencies selected from the standard curriculum. This is called curriculum modification. Additionally, pupils need to be given tools and materials that satisfy their needs.

Curriculum modification does not focus exclusively on learning objectives and contents. It also sets out all the access alterations required for curriculum development, like the environmental, material and personal conditions that improve the teaching process. We refer to such alterations (environment accessibility, materials, methodology, assessment, etc.) as "accessibility measures", and they also need to be considered as part of the teaching/learning process to be amended. Additionally, remember that this modified curriculum is sometimes far removed from the standard curriculum. It is a statement of the minimum abilities and skills that a pupil should/can acquire, with the necessary assistance, to be able to lead an autonomous life.

Curriculum modification, and consequently the education of people with SEN, clearly involves many elements from the physical and social context. The integration of this context information would give educators of SEN pupils a reference for designing curriculum modifications and provide intelligent systems with a source of reasoning, explanation and decision making for curriculum design. These ideas have led to partial solutions in this field like [1, 2].

Digital media are a very useful tool for teachers to exploit in the classroom to educate SEN pupils. They offer multiple representations and manners of interacting with the content. However, there are few tools today that take into account all the factors involved in curriculum modification. Therefore, many educators have elected to amend their own materials, whereas others have even carried on teaching without accessible materials. This is an outmoded and costly situation in which educational communities grow based on individual knowledge rather than collective and collaborative experience [3].

We believe that the best way of tackling and overcoming the numerous weaknesses present in SEN pupils' educational process is to take into account all the factors involved in the education of these pupils and the interrelations between all the elements.

In this scenario, there are, from our experience-based viewpoint [1, 2, 4, 5, 6], two major problems:

- *Provide educators with tools* for (1) guiding them through curriculum modification, (2) selecting which materials to use, (3) choosing which assistive technologies (hardware and software) to employ and (4) deciding how to go about teaching depending on the pupil's characteristics and the skills and the knowledge to be learnt.
- *Provide software developers with a methodology* to develop materials, tools and multimedia applications to improve the skills and knowledge of the SEN community.

The first point targets educators and will consist of a knowledge-based system that will provide recommendations and guidance for successfully undertaking the learning process with the pupil. The second point obliges us to formulate a special-purpose methodology to achieve, through the use of ICT, an overall and comprehensive improvement of the entire educational process for pupils with SEN. This methodology will cover all the necessary steps from curriculum modification to the generation of ICT tools to support curriculum development in the classroom.

In this article, we will give an overview of the elements that are relevant for curriculum modification. This way, we will be able to develop modified resources that have a good chance of being successful. In conclusion, we will explain the results of applying our development philosophy and how to use the acquired knowledge to build an expert system designed to make recommendations for educators.

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II. Related Work

Some solutions, ranging from curriculum modification to accessible hardware and software tools selection, have been developed to support the teaching process. Up to now though, all of these approaches are partial solutions. None of them connect the whole process or share knowledge from one step to the next. They deal with one or more (but not all) steps of the teaching process. All of these tools work independently. This is the main problem facing education for people with SEN.

A. Curriculum Modification

Curriculum modification is a key requirement for people with SEN to be able to access education. For instance, changes in how the higher education curriculum is designed in the United Kingdom are discussed in [7]. Several research institutions and groups have worked on the "Teachability project", a guide for academics specifying what aspects should be amended to get an accessible curriculum for students with disabilities that meets their learning needs.

B. Educator Support Tools

Proaci [8] and ALBOR [1] are prominent software tools related to this subject matter. Proaci is a computer program aimed at helping teachers to design individual curriculum modifications and generate the necessary documentation (recording an argued proposal by the pupil's tutor, proceedings of the meeting to decide whether or not a curriculum modification should be devised, the pupil's level of curriculum competency, amended attainment targets, amended assessment criteria, sequencing of amended contents and proposed activities).

ALBOR (Barrier-Free Computer Access) is an intelligent system that searches for assistive technology solutions to give disabled people access to computers. Not only can it be used to evaluate how a SEN pupil's physical, hearing, visual and cognitive abilities can affect computer use, but it also weighs up and suggests which of the many assistive technologies are the best option taking into account the pupil's computer access abilities.

III. ICT-Based Framework Approach for Improving the Education of Pupils with SEN

Ordinary curricula, materials and methods are evidently not directly applicable for teaching pupils with SEN. To be able to teach SEN pupils, educators will need a curriculum modification, an amendment of the methodology to be applied and an alteration of the materials to be used for teaching. Teachers need help to decide on all the questions related to this process and assure that the pupil's educational process is all-inclusive.

To achieve this goal, we think that educators should have the support of a toolkit. The input for these tools would be a curriculum, a SEN taxonomy, a qualified assistive technologies database, and expert knowledge about teaching SEN pupils and expert knowledge about adapting ICT to jobs. As a result, the educators will be supplied with a better teaching methodology, complementary classroom activities and so on (see Fig.1).

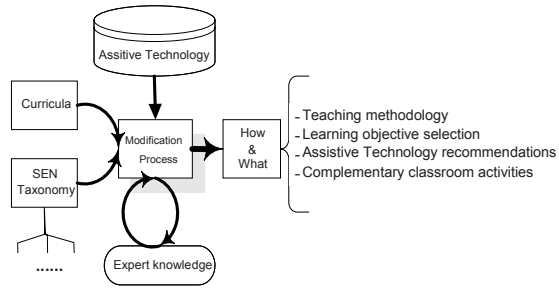


Fig. 1. Adapting the teaching process

To begin with we have to identify all the elements that are involved in the process (see Fig. 2). The conjunction of all these elements defines a philosophy and/or methodology for devising and modifying individual teaching for pupils with SEN. In the following, we outline the teaching process based on these elements.

First of all, we have to modify the curriculum. This is when the learning objectives and methodology best suited for achieving the stated objectives need to be selected. If the selected methodology uses ICT for development, it will also be necessary to select the application or applications enabling the pupil to use ICT. This modification of the teaching/learning process should be carried out for each pupil individually and for all the process situations (specific activities, educational levels, etc.). Remember that the cornerstone of our approach is the actual pupil and the skills to be developed.

To be able to establish the criteria for selecting and combining each element involved in teaching, it is necessary to establish a taxonomy to classify and correlate the different types of educational needs. In the following sections, we describe each module in detail and then propose a taxonomy of SEN types.

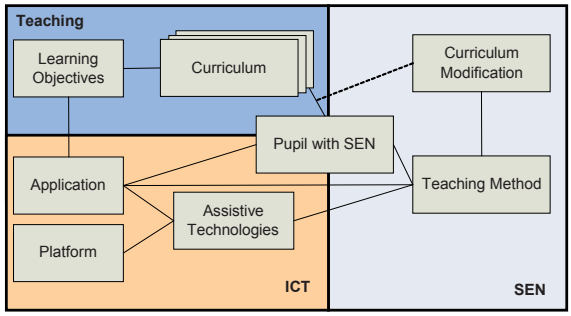


Fig. 2. Elements involved in the teaching process of SEN pupils using ICT

mmeybodi@aut.ac.ir

A. Pupils with Special Educational Needs

Pupils with SEN are defined as pupils that require, during a period of or throughout their entire schooling and particularly as regards assessment, some specific educational support and assistance because they have physical, mental or sensory disabilities or severe personality or behavioural disorders. The education system will provide the resources required for pupils with temporary or permanent special educational needs to attain the targets established generally for all pupils.

A method is a set of logically coordinated times and techniques that target pupil learning towards certain objectives. The method is what unites all the teaching and learning steps, essentially as regards the presentation and the preparation of the subject matter. Methods and techniques aim to make learning management more efficient. Thanks to them, pupils can more easily build upon knowledge, acquire the skills and internalize the ideals and attitudes that schools aim to transmit to their pupils.

The methods for pupils with SEN and learning using ICT are delimited, specifically defined and substantially conditioned in both directions.

B. Teaching

After selecting the characteristics of a specific SEN community, we must modify the curriculum and learning objectives. We must also determine what learning objectives can or cannot be aimed at depending on each pupil's (dis)abilities. To do this, it is important to establish relations between specific needs and modifications to these needs by defining a SEN taxonomy. The proposed SEN taxonomy is described later.

Curriculum: A curriculum is a structured programme of subject contents. It is an ordered series of learning objectives that are to be attained. The curriculum prescribes (or at least anticipates) the outcome of instruction. We will need to define different ways of structuring a curriculum in order to ease selection and later modification depending on the pupil's characteristics. The most important point is to determine what can be taught, what cannot be taught and what can be taught with curriculum modifications depending on the characteristics of each individual pupil. This decision will be founded on the SEN taxonomy and expert knowledge.

Learning objectives: Learning objectives are separate, self-contained, reusable parts of content for instructional purposes. These blocks are fitted together to build an adequate teaching process.

C. ICT (Information and Communications Technologies)

ICT are what will implement and instrument the teaching method defined for the learning objectives required to achieve the selected targets in the programme of study. The incorporation of ICT will provide a set of applications that will serve as tools to support learning. The pupil will require assistive technologies (AT) to be able to use these applications properly. The application-assistive technologies mix will only be available on a particular set of platforms. Therefore, a process needs to be set up for selecting the best assistive technologies for each particular situation.

Assistive technologies: To be able to use ICT as a teaching aid, pupil-system interaction will need to be altered. This modification will depend on the pupil's abilities, the platform's possibilities and the defined teaching methodology. Assistive technology refers to all those technological elements that aim to improve the abilities of people whose performance is, for any reason whatsoever, below average for the population of the same age and sex as a whole. Within the framework of ICT use by pupils with SEN, these assistive technologies are defined as tools that enable and/or improve the use of ICT by pupils for the purpose of learning. They can be hardware or software technologies and be just as wide-ranging and diverse as applications and pupils' needs and levels are. The selection of the best technology calls for a thorough and complex decision-making process to assure proper and effective use by each pupil.

Application: An application or system will be devised for use as a tool to improve or ease the learning of one or more attainment targets associated with a curriculum [2]. These applications should have been developed in compliance with recognized accessibility and ergonomics standards [9]. This way, assistive technologies can be customized for an individual pupil.

Platform: The platform model describes all the computer systems that can run a user interface. The platform model contains information about the capabilities, constraints and limitations of the target platform [10]. When developing applications for disabled people, not only must the application be ISO/TS 16071 compliant [9], but it should also provide special-purpose interaction techniques in order to be better able to meet the needs of a specific group of people. For instance, children with cognitive problems or autism perform better using a conceptual keyboard. In this case, keyboard combinations need to be provided for every element of the user interface.

D. SEN (Special Educational Needs)

The curriculum will specify what to teach and what cannot be taught depending on the pupil's characteristics. It will also establish the prerequisites for embarking on certain learning objectives.

Curriculum modification: To be able to use a curriculum properly, it is necessary to establish "how" the "whats" defined in the curriculum are to be attained. This process is what is referred to as curriculum modification, and its goal is to define the best teaching method for a SEN pupil's innate characteristics.

Teaching method: It is not the aim of this paper to define the applicable teaching methods. Teaching methods are the different techniques that make up the resources required to conduct the teaching process in an ordered, methodical and adequate manner. These methods should be used to make learning more efficient. Therefore, their inclusion in the curriculum modification is a must.

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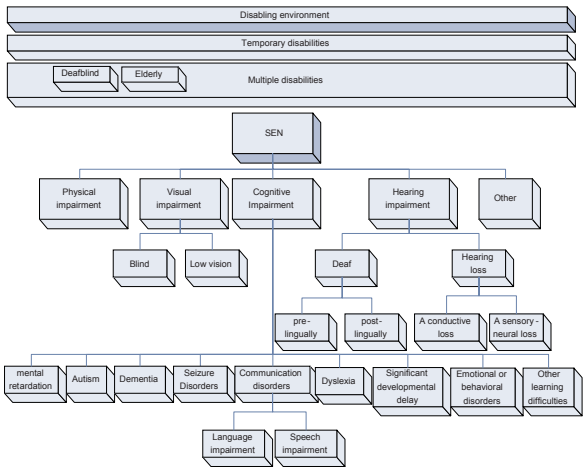


Fig. 3. Proposed SEN taxonomy

E. *Taxonomy of SEN types*

A number of authors [9, 11, 12] have classified the SEN that can influence a pupil's teaching and learning. We propose our own taxonomy (Fig. 3) based on the classifications put forward by the above authors and on our experience in developing tutoring software systems targeting people with SEN. Our aim is to cover all users with some disability and to neither over-generalize nor over-specialize by assuring that group members are similar enough as regards the curriculum modification that users require. The specific types of disabilities identified as relevant for building a curriculum modification are suspended from the SEN box. All user groups that have a combination of two or more disabilities (*multiple disabilities*) or do not have any specified disability (*temporary disabilities* and *disabling environment*) have been placed apart at the top of the figure.

IV. Case Study

Based on the philosophy described in this paper, we have developed the *Proyecto Aprender* (Learn Project) [2, 13], an educational resource targeting children with learning difficulties. This case study was developed bearing in mind pupils' needs with a view to customizing the resource (see Fig. 4). Also, a methodology for creating multimedia resources was defined and applied to the project. This project was developed for the Spanish Ministry of Education. It involved developing an accessible online resource targeting children with special educational needs. It includes an alternative curriculum modified to meet learners' needs.

The overall objective is to build up and develop the physical, emotional, cognitive and communicational skills of learners with SEN, using new information and communications technologies to promote their personal autonomy and social integration to the greatest possible extent.



Fig. 4. *Proyecto Aprender* screenshot

To achieve the main objective, it is necessary to attain other general goals:

1) Introduce ICT at primary and secondary schools
2) Develop modified curriculums to meet pupils' needs
3) Create accessible web sites and software
4) Develop accessible contents
5) Develop materials to help teachers

Other specific objectives related to pupils' skills are:

1) To establish multimedia activities related to personal autonomy, everyday problem solving and decision making.
2) For pupils to learn to live in society through knowledge of the rules of cooperation and participation.
3) To develop understanding, knowledge, linguistic skills, memory, logical reasoning and everyday problem-solving.

A. *Organization of Learning Objectives*

The learning objectives are presented as metaphors (worlds, scenarios, characters, or objects) to make the contents more appealing.

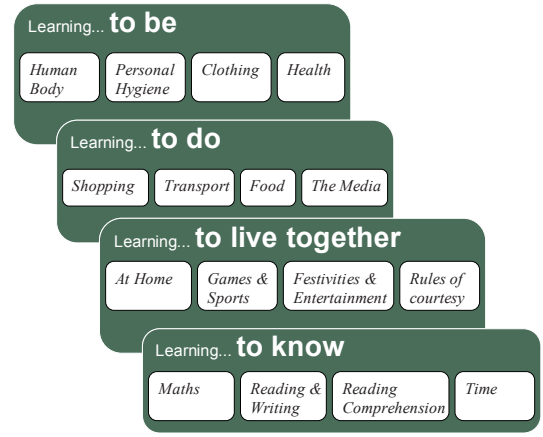


Fig. 5. Course Organization

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Fig. 5 gives an outline of the contents. At the top, learning objectives are divided into four modules called learning worlds (Learning to be, Learning to do, Learning to live together and Learning to know). Each world is divided into four scenarios. Each scenario is a learning unit.

Learning worlds have the following contents:

1) *Learning to be*: This module develops personal skills, such as dealing with feelings and tension [14]. Scenarios are presented as different interesting places visited in daily life. The scenarios and skills developed in this module are: the Human Body (Evolutionary changes, Self-esteem), Personal Hygiene (Routines, see Fig. 2), Clothing (Tidiness, Proper use), and Health (Illness, Healthy habits).

2) *Learning to do*: This module develops practical skills in which pupils apply their knowledge to interact with the environment and acquire new competencies [14]. The scenarios and skills developed in this module are: Shopping and Money (Handling money), Transport, Food (Healthy diet, Preparing simple meals), and The media (Press, Television, Computers).

3) *Learning to live together*: This module develops interpersonal skills, pointing out students' ability to interact and work in groups. These lessons also develop empathy, courtesy, friendship, cooperation and teamwork. The scenarios and skills developed in this module are: At home (Housework), Games and sports (Leisure), Festivities and entertainment (Leisure), and Rules of courtesy.

4) *Learning to know*: This module develops cognitive skills, such as decision making and problem solving [14]. The contents built into these scenarios are: Maths, Reading/Writing, Reading Comprehension, and Time.

B. Curriculum Competency Levels

Learning objects are grouped into modified levels of curriculum competency. Four levels of learning have been established:

1) *Level 1 (Stimulation).* Stimulation mainly focuses on people with severe mental disorders. The activities will involve animation-clicking on some element-answer of the animation. The task will be to recognize or identify a visual and sound stimulus, simply press the mouse or switch button and watch how the exercise is completed automatically…

2) *Level 2 (Lexicon or vocabulary acquisition).* The pupil will be required to perform a simple activity to acquire vocabulary.

3) *Level 3 (Broad contents).* Pupils will be required to perform an activity.

4) *Level 4 (Higher level activities*). This level focuses on the development of reading and writing skills or the completion of an activity where the pupil must demonstrate that he or she has acquired the skills practised in earlier activities.

C. Accessibility and Tailoring

The project was implemented as a website and a multimedia application that complies with conformance level Double A of the Web Content Accessibility Guidelines (WCAG 1.0) [15], as well as the accessibility for human-computer interfaces standard (ISO/TS 16071:2002) [9].

The pupils section includes a multimedia application embedded in a web page, where pupils access different multimedia activities organized by learning objects: skills, levels of difficulty and real-life situations.

The specific accessibility-related components developed for this project are described below:

1) *Captioning bar* (for deaf students with learning difficulties). This is a text area located in the upper part of the user interface, just above the activity area. It provides the subtitles for the audio, and several captioning features can be configured.

2) *Manual and automatic scanning* (for students with motor problems). The system moves across objects, and users use a keyboard, mouse, switch or other device to select one object. There are two scanning operating modes: automatic (works to a user-configured time) and manual (using a mouse or a switch with a button to scan and another to select objects).

3) *An audio system* (for blind students with learning difficulties). This system is used to reproduce audio describing the scene, audio explaining the activity and the background sounds in a scene.

4) *Alternative descriptive texts* (for blind people). It consists of introducing alternative descriptive texts associated with objects and activities. This will encourage the use of tools like screen readers.

5) *Contextual help* gives a clue to help complete the current activity.

6) *Configuration of accessibility options* makes it possible to configure the application to meet the pupils' needs, taking into account the abilities and disabilities of a particular pupil.

Finally, special care is taken over the presentation of the content. We have adhered to pedagogical guidelines, apart from the above-mentioned accessibility standards. With regard to text format, for example, capital letters were used at early learning levels and language was adapted for each level. With respect to illustrations, contrasting colour, style guidelines and contrasting lines were used.

V. Conclusions

Educating people with SEN is a complex task even for experts and educators. Each pupil's education should be individualized depending on his or her characteristics and abilities. This would enable a more effective use of platforms and software tools built for educating people with SEN. Unfortunately, none of the earlier proposals connect the whole teaching process or share knowledge from one step to the next.

In this article we have identified the elements and relations that denote the educational needs of SEN pupils. The philosophy and ideas described here are based on previous research [1, 4] and have been applied to develop several projects aimed at educating people with SEN, *Proyecto Aprender* [2, 13] and its continuation *Internet in the Classroom* [16, 17]. As part of these projects we are creating a formal methodology for developing accessible applications

mmeybodi@aut.ac.ir

that materialize the ideas defined in this paper. A model like this would give research institutions and groups a common framework covering all the elements and relations between them that are part of the context information for educating people with SEN.

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mmeybodi@aut.ac.ir

Evaluation Framework of Hypertext Access for Program Comprehension Support

Jussi Koskinen
Department of Computer Science and Information Systems, University of Jyväskylä,
P.O. Box 35, 40014 Jyväskylä, Finland, koskinen@cs.jyu.fi

***Abstract*-Hypertext consists of text fragments connected by links enabling fast nonlinear browsing of the fragments. In case of program text there are many alternative ways to form the fragmentation and linkage. Transient hypertext is a general and well-grounded approach for offering capabilities to form versatile information access support for many kinds of central software maintenance activities. Transient hypertextual access structures (THASs) are data structures formed automatically based on situation dependent information needs of the users of program comprehension support tools. The approach has been implemented in HyperSoft system. It is aimed at supporting legacy software maintenance and comprehension. The paper presents a detailed hierarchical theoretical framework for evaluating different THAS types. The represented framework systematically covers usefulness, benefits, costs and generic quality factors affecting the usefulness. The use of the framework is illustrated by applying it in case of a representative THAS type. The example THAS has been generated and studied by using the HyperSoft system. The framework supports systematic evaluation and comparison of THAS types and similar data structures.**

I. Introduction

Software maintenance is a very important part of the software life-cycle. The relative amount of maintenance costs has traditionally been estimated to be around 50-75%, and more recently sometimes even as high as 90% [1] of the total life-cycle costs. Solving the problems related to the maintenance and modernization of large-scale industrial legacy software is hard and central for reducing the costs [2]. Program comprehension in turn is a necessary precondition for successfully performing most of the maintenance activities.

There exists numerous tools for supporting the software maintenance and program comprehension processes. These tools often apply various *reverse engineering* techniques. Typically these tools use source code as an input and represent various abstracted and visual views and graphs for the tool user. Elements of the graphs may be connected such that browsing between them is enabled. Traditionally in software engineering context hypertext has been formed manually aided by so-called *software hypertext systems*, such as ISHYS, DIF [3] and those mentioned in [4-5] mainly for documentation, and redocumentation purposes. More recently also systems enabling automated formation of the hypertext structures based on the actual source code have appeared. Some of these tools provide views which include hypertextual links. These kinds of tools are described in [6-8].

We have earlier developed a well-grounded and sophisticated automated approach to form so-called THASs (*Transient Hypertextual Access Structures*) [9]. THASs are data structures formed temporarily based on the situation-dependent information needs [10] of software maintainers. They are used in accessing and representing the relevant parts of the maintained program. THASs are instances of *THAS types*. We have earlier charted the theoretical possibilities of forming different THAS types for different programming languages, as described in [11]. HyperSoft [12] which is an empirically validated [13] implementation of the approach provides many important THAS types. The approach has three main benefits: 1) automated formation eliminates the elaborate manual linking of program text fragments, 2) it helps to reduce the amount of the needed information stored in reverse engineering tools, and 3) it helps to ensure that the generated navigational structures remain up-to-date for the tool user.

This paper provides a detailed hierarchical framework for systematically evaluating the usefulness of THAS types, and similar data structures which can be used in reverse engineering tools. Section II presents the framework which includes central relevant factors, i.e. attributes of THAS types affecting their usefulness. Section III presents an evaluation of a representative example THAS type, based on the framework. Finally, the paper is concluded in Section IV.

II. Evaluation Framework

The final goal of using THAS-based approaches and tools is software maintenance task performance improvement. These sort of improvements have already been validated empirically in case of some of the typical information retrieval tasks and the most important THAS types as implemented in HyperSoft system [13]. This paper provides an even more comprehensive and detailed treatment of the subject on theoretical level. In this section we represent and discuss the central factors affecting successful design and implementation of useful THAS types. These factors include basic characteristics of THASs and THAS types.

The relevant factors are organized into a hierarchical framework. The purpose of the framework is to support taking

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the relevant factors into account, to systematically evaluate the likely *usefulness* of given THAS types, and to enable comparison of their usefulness. The process of applying the framework will produce an estimate of the usefulness by evaluating *quality* subfactors. Evaluations are performed in their basic form as expert judgments. Each factor ($f_1, f_2, \ldots f_n$) is given a value of quality on scale: 0.0 ... 1.0. Since the model is hierarchical, the evaluation of each factor can be refined stepwise based on a deeper level analysis; depending on the needs and resources available to the specific evaluations.

Given factor f at a level k, and ns_f subfactors at level k+1, directly under f, the quality value of f can be formed as an average of the quality values of the level k+1 subfactors. In that case each of those factors (f_i) should also be given a weight w_i, which can be determined in a similar fashion. The default weight (w) for all these subfactors is w_f / ns_f. The following subsections present the factor hierarchy. Subsection II.A. corresponds to the level 1, subsections II.A.1.-II.A.3. to the level 2 *etc*. Usefulness, and practical value of a THAS type is dependent on the quality of many factors. The purpose of a THAS type is to provide relevant and useful information for the tool user in a convenient form. It should provide support for those practical situations which it is targeted at. The practical value of a THAS type; or a single THAS, may be judged based on the achieved *benefits* and implied formation *costs*. Related to the costs high quality means low costs.

The usefulness of a THAS type finally affects task performance, which in turn can be characterized by *reduced required time and effort* and *increased quality of program changes*. Spared time and other effects in case of some important THAS types have also been studied empirically as reported in [13]. The value of the whole provided THAS set, creation algorithm of a specific THAS type, specific THAS instances and their generation in special situations can be judged in a likewise manner. Therefore, the potential scope of applying the framework is wide.

A. Benefits

Benefits of a THAS type are affected by the following factors. *Relevance*, refers here to the pertinence of the general type of data contained. *Accuracy*, refers here to the specific characteristic of the THAS's data content. *Completeness*, refers to the average quality of the THAS type in a sense of containing all expected information based on its specification.

A.1. Relevance of a THAS type can be estimated based on *supportable maintenance tasks*, and them in turn based on *covered information needs*. They represent the situations where the actual information requests passed to the support environment are satisfiable based on the THAS type [10].

A.2. Accuracy is determined by the technical possibilities and reflects whether only relevant and correct nodes are included into a THAS. Depending on the THAS type and creation algorithm; or its variant for the THAS, a THAS helps, in some degree, to confine the information space which the tool user needs to check-out. This can be described by *focusing ratio*, which reflects the typical size of a THAS instance as compared to the size of the whole potentially relevant information space. It is an important consideration due to the typical need to focus attention and spare mental resources during maintenance. For example, in case of forming *program slices* [14] there is a trade-off situation between whether to form highly accurate slices, with better focusing ratio, or to form less focused slices faster. The values of these attributes often vary among the case of forming THASs of some specific THAS types, most notably program slices, based on different *seed* information. Here seed refers to the starting point and conditions of THAS formation. Therefore, these attributes should be valued based on average case information. Especially in case of program slices, the seed information, *i.e.* the point from which the generation of a slice is started, has great effect on the nature of the outcomes.

A.3. Completeness is determined by the technical possibilities and reflects whether all of the required nodes are included into a THAS. Likewise as in case of accuracy, it may be risky to compromise over completeness in favor of execution speed. Since software can be very sensitive to small changes, these kinds of uncertainties may seriously endanger the reliability of the conclusions made based on the provided information. On the other hand, due to the nature of the most complex program analyses, such as static forward slicing of large programs, the use of rules of thumb in filtering the information space can not be avoided if results are expected to be produced within a practically tolerable time limit.

B. Costs

Costs refer to the required resources during the formation and comprehension of the THAS type. They may render an otherwise promising THAS type useless in practice.

B.1. Required time further divides into *required run time* and *required user time*. *Available central memory* affects the speed of forming complex THASs. Some general estimates validating the general applicability of the approach in this sense are given in [9].

B.2. Space complexity is an important consideration, since the support of a versatile THAS set easily necessitates storage of very large amounts of information, especially in case of static slicing. This factor can be subdivided into: *Required central memory*, and *required disk space*. Modern mass memories enable proper storage of THAS types and related required information even for very large programs.

B.3. Cognitive complexity relates to the problems with the interpretation of the presented information and interactive use of the support environment. Cognitive complexity is mainly affected by *information request complexity*. Formation of a THAS is initiated by the user by formalizing his or her information needs into the form acceptable by the support environment as legal *information requests*, which provide the necessary seed information for the THAS formations. This information may vary depending on the variant of creation algorithm of the THAS type. The information request type determines the general type of information needed in initiating the formation of a THAS type.

mmeybodi@aut.ac.ir

In HyperSoft system [12] the seed typically is a variable or function occurrence within the program text and the desired THAS type is selected from a list. The formation can be further delineated simply by specifying a *filter*, which is a set of conditions. These conditions may *e.g.* specify the modules or functions which are to be taken into the analysis. The use of *query languages*, like [17] requires more skill and takes more time, but provides a greater spectrum of options and more precise outcomes. E.g. in case of total call graph THAS, a tool user could simply initiate the formation from a predetermined menu. If partial call graph is needed, a further selection of the top-level function to be included is required. Further selections could specify the subtypes to be produced.

C. Generic factors

C.1. Type of analysis may be, for example, text search, lexical-, syntactical-, or semantical analysis. When source code is used as an input, a further characterizing feature is *static analysis* vs. *dynamic analysis*. THASs produced by the HyperSoft system [12] are formed based on static analysis.

C.2. Available information sources and input forms are used by maintainers and reverse engineering tools. Therefore, the availability of the information in a proper form is a precondition for duely selecting a specific THAS *creation algorithm* as a basis for designing a new THAS type. Therefore, this issue needs to be considered sufficiently early. The formal documentation is, in principle, suitable as a basis for the automated formation of THASs. Hypertext can, in some cases, be formed automatically also based on the information extracted from; free-form or structured, documents or texts written in natural language, as described in [15]. Available input forms affect indirectly all other factors. Source code provides the most exact description of the input system. In case that the source code is utilized, the applied *programming language* is obviously relevant. Different programming paradigms produce different program dependencies and therefore different kinds of THAS types are consequently needed in their support. A comprehensive general classification and characterization of different program dependencies is provided in [9].

Attached high quality comments improve the comprehensibility of the source code considerably. In case of legacy systems, however, sufficient documentation or comments are often unavailable. The candidate algorithms for forming the THASs require availability of specific kind of input. Due to the long generation time of some THAS types it is; in some cases, useful to pre-determine and store part of the needed information within an *intermediate input form*. That form is used to store the needed information for multiple tool use sessions. Often used intermediate forms are *parse tree* (or *abstract syntax tree*) and *symbol table*. In case of forming program slices, a much used intermediate form is *program depencency graph* [16].

C.3. Produced THAS form represents the final outcome of generating a THAS type by applying a selected creation algorithm. THAS types can be further characterized based on properties such as their: size, complexity, and topological form. A THAS type may correspond to, e.g.: simple reference, set, ordered list, tree or more complex graph with possible loops or some other abstract data type. THAS form obviously determines the intended content of the THAS type at general level. Characterizations of the possible topological forms of some of the possible THAS types are provided in graph theoretical terminology in [11].

C.3.1. Nodes of THASs contain textual information. For example, in case of call graph type THAS they contain *function identifiers* within the program text. Nodes make the decomposed structure of the input text explicit. Nodes are formed based on some selected fragmentation principle of the input text. In case that the input text is source code, a convenient basis for the fragmentation is its syntactical structure. Then, the node types of a THAS type correspond to the syntactical types of the supported programming language [9]. The size of the nodes may vary greatly, *e.g.* in C *compound statements* can be almost arbitrarily large and therefore poor candidates as usable access nodes.

C.3.2. Links connect *start nodes* and its *destination nodes*. Links explicitly show the dependencies between the nodes and enable hypertextual browsing capabilities. In case that the input text is source code, the links can be formed based on program dependencies between the nodes [9]. *Link types* relate to a THAS type. The nature of the program dependencies which are used to this purpose affects the form of the convenient linkage. Typically, a certain link type is related to certain *node types*. The semantics of a link is determined by the link type. The program dependencies that form the basis for forming hypertextual link types are analyzed and classified in [11]. Some of the nodes and links may be formed statically, *i.e.* so that they exist on default within a certain THAS type regardless of the specific situation. For example, a program slice may be supplemented with a link chain connecting the functions which contain parts of the slice based on the corresponding calling dependencies.

C.3.3. Creation algorithm affects most of the attributes of the THAS type. For example, depending on the available input information, different algorithms may have to be used, which in turn may have effect on THAS form, appended nodes, quality of the outcome *etc.* Nodes which satisfy *inclusion conditions* are appended into the THAS and those which meet *linkage conditions* are linked together with a hypertextual link. The algorithm also determines *node traversal criteria*, *i.e.* which candidate nodes are traversed or skipped during the formation of the THAS. The inclusion may be determined based on: the node type, some other attribute related to a node, existence of a dependency between two nodes, or following the dependency relations and by applying situational conditions. E.g., in case of forming program slices, the seed is the so-called *slicing criterion*, which typically is a variable occurrence in some program point, and the formation is guided by following the *control flow* and *data flow* dependencies between the elements and taking into account the current relevance of variables during the formation of the THAS.

mmeybodi@aut.ac.ir

III. Evaluation of an Example THAS type

In this section we shall first briefly introduce the HyperSoft system. Then, an example THAS type is analyzed and evaluated based on the experiences regarding it as received via the use of HyperSoft, and application of the evaluation framework. The THAS approach has been implemented in HyperSoft system, which is an experimental reverse engineering tool [12]. It consists of about 34,000 LOC of C and C++ code. HyperSoft's capabilities include support for analysis of error-free ANSI-C programs. HyperSoft system has been illustrated *e.g.* in [13] and described in detail *e.g.* in [12]. HyperSoft's current THAS set includes call graphs and program slices. Call graphs are useful in general program comprehension support. Navigation is supported in HyperSoft via various mechanisms, including back-tracking, history lists and abstracted views linked to the program text. These mechanisms enable efficient use of the information stored into the formed THASs.

We use as an example THAS here a *partial forward call graph*. It has been formed for a 2,700 LOC example chess program written in C. The example THAS type is representative and a representative THAS instance of that type has been formed automatically by the HyperSoft system and illustrated in Fig. 1. In HyperSoft the situation-dependently relevant program parts are high-lighted as nodes, and their dependencies as arrows. The root of the example THAS instance is the node *find_moves* within the module *eval.c* in the top-left window.

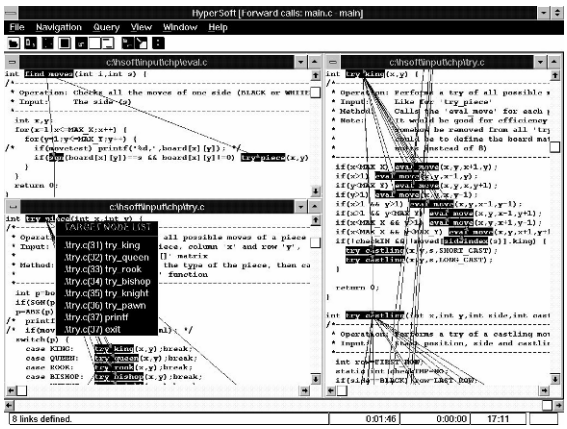


Fig. 1. Partial forward call graph as an example THAS instance as viewed through the HyperSoft system.

The structure contains those function (and procedure) calls and function (and procedure) implementations which are transitively reachable by following calling dependencies (here, for example: *try_piece*, *try_king*, *try_castling* and similar dependence chains). There are 134 nodes, 205 links and 29 calling paths in the structure. The formation took about one second. For the sake of brevity the details of the example THAS are not described here. It is illustrated more throughly in [12]. It can be traversed in various non-linear ways by the tool user by following the links generated by the HyperSoft system.

We shall characterize and evaluate the example THAS type in the following subsections whose numbering corresponds to the previous section. We discuss the issues of the evaluation framework which are most relevant to this case. Earlier empirical tool user judgments gathered as reported in [13] show that this THAS type is in this sense the most useful of the THAS set provided by the HyperSoft system (v. 1.0). Therefore, its relative theoretical usefulness can be expected to be very good. Usefulness can be determined and cross-checked based on characterizing it via the evaluation framework.

The derived estimate of the total usefulness value of this THAS type based on the use of the evaluation framework is a sum of the lower level estimates received based on bottom-up gathering of the weighted quality values of the subfactors as presented in the following subsections. The Appendix shows the basic quality (q_b), weight (w), and weighted quality (q_w) for each judged and derived factor. The basic qualities used here are based on the views of the developer of the THAS-approach with about 15 years of experience in developing the THAS types. Their main purpose here, however, is just to enable the demonstration of the use of the framework. The actual values and weights may somewhat vary and be calibrated depending on the relevant background experience and emphasis of the experts actually using the framework.

A. Benefits

Achieved benefits have been validated objectively by using a model of maintenance task performance efficiency in case of typical information retrieval tasks. The model used the following measures: completeness of the search results (*i.e.* degree of "true positive hits"), error rate (*i.e.* degree of "false positive hits"), and used time. The empirical results show statistically significantly or highly significantly better task performance while using this THAS type as compared to using conventional text search instead [13]. The results received by applying the framework also show high quality.

A.1. Relevance. Covered information needs are the following: 'List of routines that call a specific routine', 'A general classification of routines and functions such that if one is understood, the rest of the group are understood' and 'Call graph display'. The above mentioned three information needs cover about 14% (64 out of 448 elementary needs related to the top-24 information needs) of those observed by von Mayrhauser *et al.* [18] determined based on their frequencies as gathered in [10]. There are multiple related supportable maintenance tasks. Call graphs support *e.g.* general program comprehension efforts by providing a way to systematically follow the so-called *top-down comprehension strategy* [18]. General program comprehension is important especially *e.g.*: in case of starting the comprehension efforts of an unfamiliar program, while interpreting large programs and while performing impact analysis. Call graph is the traditional, well-

mmeybodi@aut.ac.ir

known and much used representation form. Therefore, the relevance of this THAS type is high.

A.2. Accuracy. Based on the analysis of the formed and tested THAS instances, there are no "false positives" (extraneous nodes), and therefore accuracy is good. Also, by delivering a partial, user-selected call graph the focusing ratio is improved as compared to the nominal, conventional way of formation. The dark side of the conservative analysis is that it undermines the focusing ratio in some degree. Main restriction is that since only static analysis is performed, function pointers are not calculated and some function calls which might never be executed may also be included into the THAS.

A.3. Completeness. There exists many variants of call graphs [19]. It is important that automatically formed call graphs are such that their users know what can be expected. The call graph should correspond to its declared definition in terms that it contains all the function calls which it is expected to contain, therefore meeting its requirements of completeness. HyperSoft applies the principle of conservative analysis. It refers to the program analysis which aims at best possible completeness. Therefore, the specification of the implemented THAS type is that it contains all the function calls which might occur given proper variable values. The example THAS type is a selected subset of the total call graph. Therefore it contains the expected nodes, with the following minor exceptions, which are noted in its specification: functions whose implementations are not included into the sources, and the implementations of functions defined in C standard header files are not included into the THAS.

B. Costs

B.1. Required time. Significant time complexity problems were not met while testing the THAS type with 2,700 LOC and 11,300 LOC programs [9]. Program dependency graphs (PDGs) or other similar structures can be used as an intermediate input form, if efficiency needs to be boosted. Many call graph extractors use additional statically derived information. As noted, also HyperSoft stores versatile information in form of abstract syntax trees. Required user time is reduced in HyperSoft such that the user may let the THAS formation to go on as a background process.

B.2. Space complexity. This factor has not been a problem. Call graphs of even very large programs are nowadays quite manageable, although it would be better if they could be kept in central memory for speed, which however is always not possible due to the costs of the central memory.

B.3. Cognitive complexity. This factor is in case of total call graphs for large input programs typically very problematic. Graphical diagrams may be hard to understand due to the great amount of overlapping arrows. On the other hand, the cognitive complexity of forming information requests is here very small. HyperSoft alleviates these problems also by providing partial access structures and hypertextual navigation. HyperSoft provides the traditional graphical call graph, which is additionally linked to the program text and hypertextual representation of the THAS. HyperSoft also supports understanding by providing the so-called *local views* and *abstracted views*, as demonstrated *e.g.* in [10]. These views show a condensed subview with focus selected by the user. The relative complexity as compared to other THAS types may be evaluated based on the number of node types and link types involved.

C. Generic factors

C.1. Type of analysis. The applied analysis is standard static traversal of an abstract syntax tree and related symbol table information.

C.2. Available information sources and input forms. Source code has to be available as an information source. Abstract syntax tree and symbol table should be available as input forms, and usually they are. Other information sources or manual intervention of the analysis are not required.

C.3. Produced THAS form. In HyperSoft the supported programming language of this THAS type is C, which is a conventional imperative programming language with clear calling structures. Therefore, the *produced THAS form* is here a simple tree. Inclusion criteria for the *nodes* (C.3.1) is: function identifier type nodes, transitively reachable from the seed of the THAS via following the relevant link types. *Links* (C.3.2) are formed based on: Function calling dependencies and structural inclusion (*i.e.* function calls appearing within a specific function context) are determined. In turn, nodes are bound together based on the determined link types. Therefore, the number of node types and link types involved is low. Also the complexity of the nodes is very low. Therefore the relative complexity of this THAS type is low. While the information stored into abstract syntax trees and symbol tables is available the *creation algorithm* (C.3.3) of this THAS type is relatively uncomplicated and therefore also fast.

D. Discussion

The evaluation framework has guided well the evaluation by supporting taking into account the many aspects relevant to usefulness of THASs. The example THAS type is based on a traditional well-known form and is therefore communicative. The relevance of the THAS type is high, based on the kind of general purpose information that it contains. It supports a relatively large portion of the empirically verified important information needs of C programmers. Its usefulness has been earlier validated also via both subjective and objective empirical data gatherings. Consequently, it provides support for many central maintenance subtasks. Time and space complexity problems are not to be expected, at least in case of well-modularized average sized conventional software. Cognitive overhead of dealing with the structure can be significantly alleviated by using the mechanisms specifically offered for this purpose by HyperSoft. Its basic form is relatively simple and its formation is relatively fast. The THAS type is here intended to support maintenance of C programs, which are very important in terms of the volume of the legacy code still in use and frequency of the difficulties confronted in maintenance. The THAS type can be produced; in its basic form, based on pure static analysis. Only

mmeybodi@aut.ac.ir

precondition is the availability of the source code or the corresponding intermediate PDG-information as an input.

IV. Conclusion

Software maintenance and program comprehension can be supported via automatically formed transient hypertextual access structures (THASs). We have earlier presented principles of forming THAS types based on theoretical possibilities [11], and implemented [9,11] and evaluated [10,13] an experimental tool; HyperSoft. Transient hypertext is a general and well-grounded approach offering capabilities to form versatile information access support for many kinds of central software maintenance activities, such as program comprehension [10] and impact analysis [20].

In this paper we have explicated the central factors affecting the usefulness of THASs, and formed a detailed evaluation framework for taking them systematically into account while designing useful THAS types. The application of the framework has been demonstrated with respect to analytically evaluating a representative THAS type; a partial call graph. Its use scenario has been produced by HyperSoft. The evaluation has provided an enhanced view of the feasibility of that specific exemplary THAS type. The use of the evaluation framework also produces a sort of quality profile for the evaluated THAS types. The evaluation has also provided information of the application of the evaluation framework itself. Its application has been straightforward and it has well supported taking into account the numerous details and aspects which are relevant in these kinds of evaluations.

Other THAS types could be evaluated via applying the framework in a similar fashion. The THAS types and similar data structures could also be produced by any reverse engineering tool enabling formation of information requests, and handling of the produced results as a directed graph enabling nonlinear browsing capabilities similar to HyperSoft. The here presented evaluation framework enables systematic evaluation and comparison of potential new THAS types to maximize their likely usefulness in the light of the current program comprehension theories and general practical reverse engineering requirements. Although empirical evaluation clearly is not within the scope of this paper, it would naturally be useful if additional expert judgments regarding the average non-derived basic quality subfactor values and factor weights for specific THAS types could be gathered in the future. That would enable formation of an expert judgment data base as a basis for long-term improvement of the hypertext access support provided by reverse engineering tools.

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Appendix: The THAS Evaluation Form

Table I. The THAS Evaluation Form for the Example THAS Instance

Section/Factor (f_i)	Level (k)	Basic quality (q_b)	Weight (w)	Weighted quality (q_w)
USEFULNESS	1	(0.853)	(1.000)	(0.853)
A. Benefits	2	(0.867)	(0.333)	(0.289)
A.1. Relevance	3	0.940	0.111	0.104
A.2. Accuracy	3	0.700	0.111	0.078
A.3. Completeness	3	0.960	0.111	0.107
B. Costs	2	(0.760)	(0.333)	(0.254)
B.1. Required time	3	0.800	0.111	0.089
B.2. Space complexity	3	0.880	0.111	0.098
B.3. Cognitive complexity	3	0.600	0.111	0.067
C. Generic factors	2	(0.933)	(0.333)	(0.310)
C.1. Type of analysis	3	0.940	0.111	0.104
C.2. Inf. sources and forms	3	0.920	0.111	0.102
C.3. Produced THAS-form	3	0.940	0.111	0.104

1 The derived values are given in parentheses.
2 The non-derived basic qualities are given by the user using the scale: Weak (0.00…0.49), Sufficient (0.50…0.59), Satisfactory (0.60…0.69), Good (0.70…0.79), Very good (0.80…0.89), and Excellent (0.90…1.00).
3 The derived basic qualities are calculated as averages of the subfactors.
4 The non-derived weights may be calibrated based on expert judgments.
5 The derived weighted qualities are calculated as sums of the subfactors.

mmeybodi@aut.ac.ir

A Model for Multiplayer Interactive Games in Cellular Wireless Environment

Vaddadi P. Chandu
University of Maryland
College Park, MD
chandu@terpalum.umd.edu

Karandeep Singh
University of Maryland
College Park, MD
ksingh@mail.umd.edu

Abstract

Cell phones are much more than mere communication devices today. Modern phones come with entertainment features including games that are so popular that their primary function (communication) has practically become secondary. Readily available networking capabilities further make this platform highly promising for gaming. The first wireless game called 'Snake' was releases in 1997 as an embedded application for Nokia phones. After Snake, there came a slew of other games for cell phones. As demand for handsets with interesting games grew, development community started working on bridging the gap between the software and hardware. And soon technologies like WAP, SMS, and MMS were developed. Today, we are heading towards real time multiplayer games which would eventually become 3D in the future. There is a need of an effective and scalable generic model for design of games. In this paper, we propose a generic model, which is based on the 'client-server' model and is scalable, layered and completely extendable, for implementing games in a cellular wireless environment.

1. Introduction

Games in cellular environment can be broadly categorized based upon (a) play mode, (b) technology. Based on play mode, games can be further categorized based on the number of players involved. *Single player games* never need the network, and hence are easy to design and implement. In *Pseudo multi player games,* players may be given an impression that they are playing in a multiplayer environment, but in fact they are playing in solo-environment. Their scores can be compared with other players in the end. Such games have been very successful, for example AOL's Slingo. In *Fixed turn based multi player games,* the players take turns in playing. For example, in a game of chess, it is easy to figure out whose turn is next, and a small delay here is tolerable. *Simultaneous action games* are most complicated to design. In this kind of games, every player can act simultaneously, and hence delay cannot be tolerated. There has to be a central service that arbitrates the game state, else there is a risk of game state drifting. Latency can't be tolerated here. In Online/Offline games players may act whenever they wish. Even offline, they have access to the gaming world. The game may last a long time, days, even months. An example is Dataclash, a WAP game from NGame where a player builds his defense when signed in but can attack defenses of other players even when they are offline.

Cellular gaming comes with many challenges that can be safely ignored in gaming over conventional platforms like PC. Primarily, it is the network latency and low bandwidth, followed by the limited resources, like screen size, CPU power, and static and dynamic memory availability. These cause several limitations for cellular game design: (a) keep play times short, (b) avoid games that are latency crucial, (c) keep game small, avoid games requiring high amounts of memory, (d) optimize game for multiple devices, (e) design the game so that it can be localized easily into the native language of a country, (f) allow easy interruption and resume features, (g) incorporate proper zooming levels into the game, and finally (h) proper networking scheme depending upon the game requirements.

This paper presents a robust *environment-independent* model for cellular interactive gaming that addresses the challenges mentioned above. The rest of the paper is organized as follows: Section 2 describes the existing approaches for game networking, Section 3 describes the challenges encountered by games in cellular environment and the development approach for a game designer, Section 4 describes the available cellular environments (operating systems), and Section 5 presents our proposed model for cellular wireless gaming in detail followed by conclusions and future work in Section 6.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 241–248.
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mmeybodi@aut.ac.ir

2. Existing Approaches for game networking

2.1. Server Driven

This model uses the client-server approach [17] [18]. Each player is a client and a central server takes responsibility of game state processing. Each of the clients communicate with the server with its moves, and the server periodically processes the client inputs, computes game state and pushes the state to all clients. With this approach, the clients are freed from the task of maintaining state. Only server handles the state, which avoids the problems of stale game state and game state drift. Since each client communicates server only when there is a move, bandwidth is conservatively used. The main disadvantage is the need of a server, and the cost of setting up, operating and maintaining it.

2.2. Peer-to-Peer

In this model [17] [18], the overhead of paying for the server is avoided by making each player a peer to others and no one is a supervisor. Each player, on making a move sends this information to every other player. All players now compute and update their game state and thus remain in sync. While the bandwidth and hardware is supplied by the players; security, synchronization, and replicated computation of game state is required in all devices. Also, due to the peer-peer model, data transmission is exponentially proportional to the number of players unlike in the previous model. For example, with an increase from n players to $(n+1)$ players, the traffic increase is from $n*(n-1)$ to $(n+1)*n$, the difference equal to $2n$. So data compression schemes for gaming have to come into picture which is not very attractive for small devices like cell phones.

2.3. Bluetooth & Cellular gaming

Bluetooth technology [9] enables access to wireless devices in close proximity. Since devices can be at most 10 meters apart to be able to communicate using Bluetooth, it is obviously not a feasible way for cellular game players that are distant. However, this can be incorporated in the gaming, that if players are from within close proximity, the mode can switch to Bluetooth mode, although this will increase the complexity of game design significantly. Even in Bluetooth, the network latency is of the order of multi milliseconds, and all devices have to be under the authority of a master (Bluetooth has piconets and each piconet has a master controlling it). This effectively boils down to client server model although the server is not locally situated.

While cell phone devices can communicate with each other via MMS & SMS, but there is no concrete technology as of now which can ensure low-latency direct communication mechanism. Hence, peer-to-peer is definitely not an option. Moreover, since individual cell phone devices do not have IP address, they cannot be accessed directly through TCP or other connections. Hence, multiplayer gaming in cellular environment currently has server-driven model. The cellular service providers may have to set up the gaming servers and someone (service provider or customer) has to account for the additional price for multi-user gaming to be feasible on cell phones.

3. Technology available for Gaming

3.1 SMS Technology & Cellular Gaming

Short Message Service (SMS) [14], which works on a store-and-forward basis, is primarily used to deliver short text messages from one cell phone to another. All SMS messages have to go through a messaging server that repeatedly sends the message to the destination phone until it is received at the destination. While the cost of sending a message is reasonably low, there is no guarantee that the messages will reach destination promptly. It could be immediate or delayed depending upon traffic. For multiplayer games where prompt communication is essential this obviously fails. Hence, SMS technology cannot be applied to peer-to-peer model for cellular gaming.

3.2 WAP Technology and Cellular Gaming

Wireless Application Protocol (WAP) [3][4][7], is a browsing environment optimized for small devices like cell phones that have severe bandwidth and form factor restrictions. WAP games are primarily browsing games. Player goes to WAP server whose location is provided by the cellular service provider, and chooses the game of his choice. WAP client places its request using one of the protocols prescribed in WAP forums, like Wireless Session Protocol, to the WAP gateway. Gateway translates this request to standard WWW request (HTTP or TCP/IP) and forwards it to the application server. The function is more like a user inputs some queries through WAP browser and receives information requested. The return information however, goes through the process of getting assembled into appropriate WML pages for the browser to display.

Real time interaction is extremely difficult in WAP, because there is no real time access to other players move. Additionally, lack of a language that supports sockets (like Java) and lack of speed are primary limitations for WAP in the cellular gaming world. This means every communication from the player and host server is viewed as a static web page, which implies higher delays (in the order of seconds) due to loading time. While WAP

mmeybodi@aut.ac.ir

provides an interface friendlier for SMS, it is a static browsing medium having all the processing power is on the server side, which renders it inappropriate for interactive multiplayer games. However, interactive single player games can be designed well in WAP technology.

3.3 MMS Technology & Cellular Gaming

Multimedia Message Service (MMS) [16] [17] extends Short Message Service (SMS) paradigm by adding audio and visual content. Messages that are rich in multimedia content can be sent and received from either peer or a content provider. MMS message consists of a set of instructions that control the presentation and multimedia objects reference by the script. Working of MMS is similar to SMS, the forwarded messages are stored on a multimedia server and at the earliest possible opportunity they are sent to the recipient. If the recipient is MMS capable, the information is sent over WAP bearer using push technology. Otherwise, the server takes appropriate decision as to how to send the message.

MMS development needs to be carefully considered, because this needs Synchronized Multimedia Integration Language (SMIL) support, which is the language used to order and group multimedia objects. However, MMS comes with the same setbacks as SMS, and hence cannot be used for gaming.

4. Environments available for Gaming

4.1 Binary Runtime Environment for Wireless (BREW)

BREW [15] is a standalone environment developed by Qualcomm for application development within wireless environment. BREW system provides open platform for extendable applications execution platform that reside on the wireless device. It supports different device authentication and verification services and also supports digital signature verification. BREW porting kit is a tool to integrate BREW platform into wireless devices. A rich library of APIs is provided for developers and because they can port the phone's user interface directly on top of BREW, handset manufacturers and/or operators can update their interfaces directly over the air. BREW SDK gives developers development and debugging tools, sample applications with source code, reference materials and user guides as well as a phone emulator that lets developers run applications in their own development before they begin device testing.

4.2 Mophun

Mophun [16] is an environment which is designed for bridging the gap between traditional console-based and mobile games and the game-centric API and SDK help the developer in speeding up the development process. Mophun provides gamer a full 3D and 2D API, which is optimized for game execution. Mophun API provides access to features like sound support and communication. It can also access hardware, such as vibration, backlight and touch screens. The 3D features include 3D math, perspective correction, material, lighting, shading, fog, collision & occlusion, texture wrapping, blending, transparency, filtering, and a number of different rendering modes. The Mophun SDK is a non-proprietary completely free toolset built with GNU tools using open standards. It was built by game developers for game developers. Games are written in C/C++ or assembler and the software can be written and tested on a regular PC.

4.3 J2ME

Java 2 Micro Edition (J2ME) [8] is a form of the Java language that is optimized for small devices such as mobile phones. It provides better interface control than SMS and WAP, allowing animation and networking support to remote server. Popularity of Java and extensive deployment of J2ME on mobile phones from leading manufacturers provides the developer with better technical support and hence is naturally ranks top among available languages. Tens of millions of Java-enabled phones are already in consumers' hands. Applications are developed by creating MIDlets (Mobile Information Device Profile), which can be uploaded on a server and downloaded by interested users. A J2ME application can be paused at any time using the MIDlet life cycle methods. Applications can be deployed by using WAP download method. This is done by placing the Java Application Descriptor (JAD) and JAR files on a Web site. When the user points the WAP browser to the JAD file, the MIDP application automatically downloads and installs. However, other means of deployment include downloading to a PC and then transferring to the mobile phone via Bluetooth, infrared, or USB.

5. Proposed model for cellular games

Based on the analysis in above sections, we propose client-server architecture for mobile games in cellular environment. This section fully covers our proposed architecture in detail, including state diagrams and pseudo code for the building blocks of proposed architecture.

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5.1 Architecture for the model

We propose a server that acts as an independent arbiter for the group of players. The server is solely responsible for managing game state. All clients have to continually deliver events (key hits) to it. The server combines the incoming events and processes them at fixed intervals. After each interval, server updates the game state based on current and new game state, generates events reflecting changed game state. In case current game state is same as the new game state, no events is generated. This is a very effective step to save network bandwidth. The server distributes events to all clients, and clients upon receipt update the display based on the received data. Clients are totally stateless and do not keep any information, including local information. Clients are effectively, remote terminals with a screen and input keys.

Coming to the server part of the game, we split it into two modules - game processing module and networking module. While game processing module is different for each game depending upon the game logic and processing states, networking module is generic and common for all games. This module (networking) opens a socket and listens constantly for incoming connections. When it receives an incoming call, it instantiates a connection object and allows the connection object to take charge of communication between incoming call and the actual game processing module. Thus, the networking module is free almost always, except for a short period of time when there is an incoming call. If multiple players send incoming calls simultaneously, all of them are forwarded to game processing module. The module, depending on timestamps, decides order of action. Game processing module deals only with the game state processing. It is totally oblivious of the networking issues. It is also unaware of the representation of the data on client site. It deals solely with numbers. This module receives inputs at arbitrary intervals, but sends out the processed state at regular intervals to the clients. We propose a game state that contains only player's move and new location so that the interface can be kept fairly abstract from the game, and also the state can be transmitted with minimum amount of data.

Now, client side of the game is also split into two modules for ease in design- (a) networking module and (b) display module. As the name suggests, the networking module is responsible for signing in the players on to the server. The display module is responsible for (a) reading in the key hits from the player (s), and (b) interpreting the game state sent by server and updating the client screen. For communication, we propose using TCP/IP sockets as underlying communication mechanism. Sockets offer fast transfer of data with low overhead. However, sockets are not best for supporting complex data types, but we assume that any good design for a game will come with simple data types else the transmission will be very slow.

Fortunately, Java platform allows Java Objects to be represented as an array of numbers which is ideal for transmitting over sockets. These data can be again wrapped in a message structure depending on the game type for providing additional information, for example using a header, type of message and then the exact data in the message (just as data transmission over IP is done). A real game may contain a message in this format: [*Type of message, Number of Players, Co-ordinates of each player, Game Level*]. The corresponding message may look like [0, 4, 10.10, 20.10, 12.21, 12.12, 1], where a 0 in first place can be interpreted as start of the game. Likewise, depending on the game, a suitable messaging format can be designed.

In the remaining part of this section, we will present our model with objects and their description. Portability to any game has been our main design criterion which designing this model. Description of various blocks in the model is given below, and corresponding figures follow.

5.2 Model for the Client

(a) **Data**: This returns the data represented by this instance in array form so that transmission is easy over sockets. Handles all reads and writes to Sockets. This is the superclass that encompasses all other classes handling different data types that follow.

```
public_abstract_class Data {
  // convert data into array form //
}
```

(b) **stateMonitor**: This extends "Data" and handles state changes in game. Contains "Constant Types" which help in conversion of incoming array formatted data into strings or strings into array for better human readability

```
public class StateMonitor extends Data {
  // constant definitions to represent object types //
  // constant definitions to represent game status //
  // methods to parse strings and convert strings to
arrays vice versa //
  // methods to set the attributes to game state //
}
```

(c) **Snapshot**: Holds all the events between two consecutive snapshots. This object also extends "Data" so that transmission over TCP socket is made easy. A snapshot may typically be assumed to contain: (i) current number of players, and (ii) events from StateMonitor.

```
public class Snapshot extends Data {
  // methods to retrieve number of events in this
snapshot //
```

mmeybodi@aut.ac.ir

```
 // methods to retrieve number of players in this
snapshot //
}
```

(d) **Packetizer**: This object packetizes the data which is in the form of array with a wrapper containing (i) header, (ii) type (iii) special signals (iv) sequence number (v) any other. Although this is not strictly required, we propose to have this as this eases the life of programmer

```
public class Packetizer {
  // methods to add all the fields and wrap it in a
message //
}
```

(e) **ActionInterface**: This is an interface, that we propose solely for the convenience of the programmer, this converts actions into numbers. This typically has a set of constant definitions nothing else

```
public interface ActionInterface {
  // have all definitions here //
}
```

(f) **CSInterface**: This is again an interface shared between client & server, who agree to listen to TCP/IP port

```
public interface CSInterface {
  // have port number set here //
}
```

(g) **ClientEngine**: This module is practically the heart of client. This is responsible for retrieving server IP, opening connection to the server, signing up clients, instantiates the module waiting for incoming server messages. It extends the MIDLet class provided by J2ME

```
public class ClientEngine extends MIDLet {
  // method for starting up the game //
  // method for key hits from player //
  // method for pausing the game //
  // method for closing and destroying the game //
  // method to process event from other modules //
  // method to handle error //
}
```

(h) **ImageCreator**: J2ME allows creating images at runtime with pattern description given, without having to store the images in the heap memory. Using this method, heap memory can be saved by not having to store images in the memory.

```
public class ImageCreator {
  // method to initialize the color table (this has to be
set by programmer) //
//method to set pattern & create image based on it//
}
```

(i) **CNDInterface**: Another interface, between client side networking object and display object. This transfers the key stroke and action taken by the user and sends it to the "Packet" object which creates a packet out of it and pushes it off to server.

```
public interface CNDInterface {
  // method declaration to pass arguments to Packet
object //
}
```

(j) **displayInterface**: This is another interface that is included so as to keep the client generic. This interface links clientEngine and client display. This extends "canvas" class in the MID profile.

```
public class displayInterface extends canvas {
  // method declaration to update screen //
}
```

(k) **clientDisplay**: This object extends "displayInterface" and captures key events, pre-processes them and creates images necessary for game display. It also interprets server sent state and forwards them to clients main module, which further sends the state to update module.

```
public class clientDisplay extends displayInterface {
  // method for initializing the display //
  // method to handle events related to display //
  // method for updating the display //
}
```

5.3 Model for the Server

(a) **ServerEngine**: Assuming that the server contains many games residing on it, this object instantiates desired game processor, opens a socket to listen for incoming connections. If there is only one game implemented on the server, then it only opens connections and listens to it. Each incoming connection has a dedicated server connection opened for it. This pushes snapshots to clients in a distributed manner saving bandwidth. Finally, it is responsible for closing the connection when a client disconnects.

```
public class serverEngine {
  // method for instantiating game processor //
  // method for game state distribution //
  // method for closing client connection //
  // method for opening a connection //
}
```

(l) **serverEngineAssistant**: This object handles some very important tasks related to the game on server side: (i) connection between client & game processor, (ii) signs on & off the messages from client to the processor, (iii) sends message to a given client, (iv) waits for updates from clients. Thus, it masks game processor from networking tasks.

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```
public class serverEngineAssistant {
  // method for signing on and off clients //
  // method for sending messages to client //
  // method for receiving updates from client //
}
```

(m) **SEPInterface**: An interface between server engine and game processor on the server. It handles all the communications from server engine to processor and vice versa, and hence frees the game processor from communicating to the server. This object is introduced to keep the game server engine generic, changing the game processor will allow this model to work for any game logic.

```
public interface SEPInterface {
  // method declaration "game engine ↔ game
processor communication" //
}
```

(n) **messageParser**: This module is a parser for incoming data and ensures that all the representations are valid. If found otherwise it reports.

```
public class messageParser {
  // methods for parsing the message //
}
```

(o) **playerRecord**: This object handles complete record of each player. In fact each player can have one of this object instantiated for him. This includes some attributes that are required for game processing such as: location, ID, direction, lives, status etc.

```
public class playerRecord {
  // method for handling number of lives available to
the player //
  // method to handle player direction //
  // methods to handle any other game specific details
like level, status, etc //
}
```

(p) **gameEngineNetworkingInterface**: Another interface to keep game engine generic. This interface declares all methods for communicating from game engine to the networking module

```
public interface gameEngineNetworkingInterface {
  // method declaration for communication from engine
to networking //
}
```

(q) **gameProcessor**: This is the main portion of the game which contains all gaming logic on the server. Player entering, leaving, updates, logic for everything is handled here.

```
public class gameProcessor {
  // method for player entry //
  // method for player removal //
  // method for player updates //
  // method for implementing player moves //
}
```

5.4 Server State Machine

State machine of server is fairly simple. Server constantly waits for inputs from clients (assuming the server to be in running state). Upon receiving input from clients, it processes the new game state and returns it to the clients. Fig.1 displays the state machine of the server in the running state. Since initiation state is a startup state, which merely sets up a connection socket between the client and server, it is omitted here for the sake of clarity.

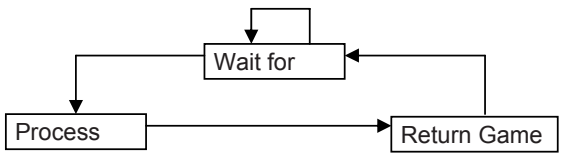


Fig.1. Server State Machine

5.5 Server Block Diagram

We propose a *3-layer* architecture for the server. First layer as seen from the client side is serverEngineAssistant, second layer is serverEngine, and third layer is gameProcessor<i>. As seen in the Fig.2,

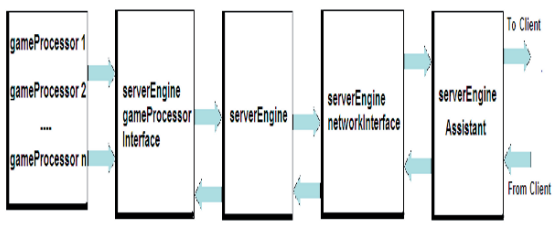


Fig 2. Server Block Diagram

serverEngineAssistant layers is responsible for the communication between clients and server (receive & send messages). Received messages are forwarded to the serverEngine for further processing via serverEngineNetworkInterface (SEPInterface, which is included merely for increasing the generality of the model). At the serverEngine layer, depending on the type of message, the engine either instantiates a game processor or computes the game state and returns the message through same steps.

5.6 Client State Machine

Client state machine is more involved than server state machine, with five states. The flow of control in the state machine is depicted in Fig.3. Client constantly waits

mmeybodi@aut.ac.ir

for player to hit a key. Once a key is hit, it moves on to next state where it calls a method to detect which key is hit. Next, it builds the event into message in prescribed format (chosen by the designer) and sends to server. Here it busy waits until server returns a reply. The reply could be an updated game state or acceptance to game. In this state machine, it is assumed that the client and server are already connected and game is running. Upon receiving reply from server, the client engine processes it and updates the screen.

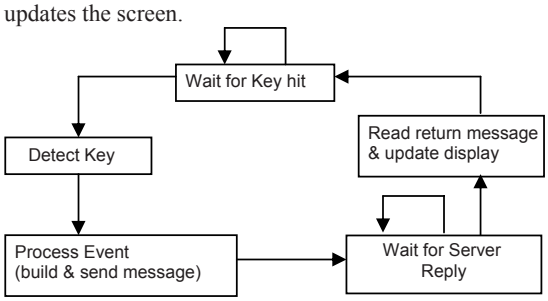


Fig.3. Client State Machine

5.7 Client Block Diagram

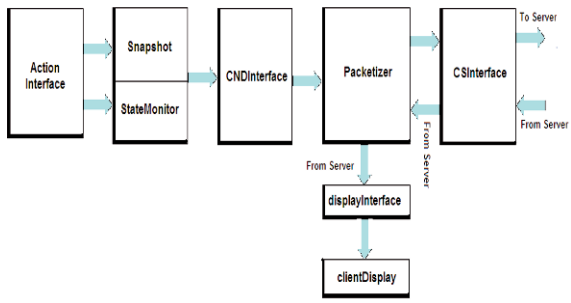


Fig.4. Client Block Diagram

Here again we propose a 3-layered architecture for the client. The three layers as seen from server side are (1) Packetizer, (2) Snapshot & StateMonitor, (3) clientDisplay. While first layer is the hub to receive and dispatch messages, second layer handles key hits, snapshots and other state related issues, and third layer handles display. As seen in the Fig.4, client talks to the server via CSInterface (CSInterface is included to enhance the generality of model). Upon receiving messages from server, they are sent to the Packetizer (Packetizer unpacks the incoming messages & packs the outgoing messages) and sends them to the displayInterface which further sends them to the clientDisplay module. This updates the screen. If the client wishes to send a message to the server, the player action goes through actionInterface, corresponding snapshot (by snapshot) and states (by stateMonitor) are recorded. This information is sent to Packetizer via CNDInterface and packed into a message. The packed message is finally sent to the server through CSInterface.

Scalability, which always is an issue with designs related to networking and distributed systems, is automatically taken care of in the proposed model. The server part of the model is completely insulated from the client side of the model. While the client side is implemented within the cellular environment, the server side is implemented within the world-wide-web environment (which is same as internet servers). Just as multiple users, thousands of miles apart on the globe can access the same location without any scalability issues, likewise multiple users can also access the gaming server in our model without any scalability issues. All the solutions that are employed to solve the scalability issues in internet servers can be employed in this case too.

6. Conclusion and future work

We proposed a generic model for games in cellular environment. As per our knowledge, we do not know of any other such generic model available for interactive cellular gaming. There are some models available for use in computer gaming [19], but they assume high bandwidth, low network latency, and high availability of other resources such as memory and processing power than what is available in cellular gaming. Hence, they cannot be used in cellular gaming without significant redesign. Our model assumes limited availability of resources and hence is well suited for cellular gaming environment.

Our model presents a layered architecture, and hence allows (a) better portability, and (b) easier code changes and updates to the game processors, user interfaces and other features. The updates can be either easily integrated or built on the top of this model without changing the basic design blocks.

This model does not speak about security in this paper, because there is no communication among clients, and server is a trusted source, the security is ensured to a great degree. However, to ensure a high degree of security, we propose (a) opening a secure connection to the server, and (b) performing a check on the incoming message for authenticity.

For this model, theoretically, there is no limit on the number of players, but due to the small size of screen, we recommend the number of players to be limited to four or at most six. While we anticipate a long time for peer-to-peer technology to work in cellular environment, it can be a possible area for further work.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

An Evolutionary Algorithm for Query Optimization in Database

Kayvan Asghari[1], Ali Safari Mamaghani[2] and Mohammad Reza Meybodi[3]
[1,2]Islamic Azad University of ([1]Khamene, [2]Bonab), East Azerbayjan, Iran, [3]Industrial University of Amirkabir, Tehran, Iran
[1]kayvan.asghari@yahoo.com, [2]safari_m_61@yahoo.com, [3]mmeybodi@aut.ac.ir

Abstract- **Optimizing the database queries is one of hard research problems. Exhaustive search techniques like dynamic programming is suitable for queries with a few relations, but by increasing the number of relations in query, much use of memory and processing is needed, and the use of these methods is not suitable, so we have to use random and evolutionary methods. The use of evolutionary methods, because of their efficiency and strength, has been changed in to a suitable research area in the field of optimizing the database queries. In this paper, a hybrid evolutionary algorithm has been proposed for solving the optimization of Join ordering problem in database queries. This algorithm uses two methods of genetic algorithm and learning automata synchronically for searching the states space of problem. It has been showed in this paper that by synchronic use of learning automata and genetic algorithms in searching process, the speed of finding an answer has been accelerated and prevented from getting stuck in local minimums. The results of experiments show that hybrid algorithm has dominance over the methods of genetic algorithm and learning automata.**

I. INTRODUCTION

Relational data model has been introduced by Codd [1] and in recent years, relational database systems have been recognized as a standard in scientific and commercial applications. Work on join operator, because of its high evaluation cost, is the primary purpose of relational query optimizers. If queries be in the conversational manner, they will include fewer relations and we can do the optimization of these expressions by an exhaustive search. However, in case the number of relations is more than five or six relations, exhaustive search techniques will bear high cost regarding the memory and time. Queries with lots of joins are seen in new systems like deductive database management systems, expert systems, engineering database management systems (CAD/CAM), Decision Support Systems, Data mining, and scientific database management systems and etc. Whatever the reason, database management systems need the use of query optimizing techniques with low cost in order to counteract with such complicated queries. A group of algorithms which are searching for suitable order for performing the join ordering problem are exact algorithms that search all of state space and sometimes they reduce this space by heuristic methods [7]. One of these algorithms is dynamic programming method which at first introduced by Selinger et al [2, 9] for optimizing the join ordering in System-R. The most important disadvantage of this algorithm is that increasing the number of relations in queries needs much use of memory and processor. We can imply other exact algorithms like minimum selectivity algorithm [7], KBZ algorithm [10] and AB algorithm [11]. Other algorithms named random algorithms have been introduced for showing the inability of exact algorithms versus large queries. Introduced algorithms in this field are iterative improvement [5, 6, 12], simulated annealing [5, 12, 13, 14], two-phase optimization [12], toured simulated annealing [8] and random sampling [15].

According the nature of evolutionary algorithms and considering this matter that they are resistant and efficient in most of the cases and by considering the works done in this field, the most suitable choice for solving this problem is use of evolutionary algorithms. The first work in optimizing the join ordering problem by Genetic algorithm has been done by Bennet et al. [3]. In general, the algorithm used by them bears low cost in comparison with dynamic programming algorithm used for System-R. Other features of this algorithm are the capability to use in parallel architecture. Some other works have been done by Steinbrunn et al. [7] that they have used different coding methods and genetic operators. Another sample of evolutionary algorithms used for solving the join ordering problem, is genetic programming which is introduced by Stillger et al. [16]. CGO genetic optimizer has also been introduced by Mulero et al. [17].

In this paper, a hybrid evolutionary algorithm has been proposed for solving the optimization of Join ordering problem in database queries. This algorithm uses two methods of genetic algorithm and learning automata synchronically for searching the states space of problem. It has been showed in this paper that by synchronic use of learning automata and genetic algorithms in searching process, the speed of finding an answer has been accelerated and prevented from getting stuck in local minimums. The results of experiments show that hybrid algorithm has dominance over the methods of genetic algorithm and learning automata. The paper has been organized as follows: The second part defines join ordering problem in database queries. Part three provides brief account of learning automata and genetic algorithms. Part 4 explains the proposed hybrid algorithm and on basis of data analysis, part 5 provides an account of analysis, in other words it deals with results. The conclusion and implication will be presented in part 6.

II. THE DEFINITION OF PROBLEM

Query optimization is an action that during which an efficient query execution plan (qep) is provided and is one of the basic stages in query processing. At this stage, database management system selects the best plan from among

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 249–254.
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mmeybodi@aut.ac.ir

execution plans, in a way that query execution bears the low cost, especially the cost of input/output operations. Optimizer's input is the internal form of query that has been entered into database management system by user. The general purpose of query optimizing is the selection of the most efficient execution plan for achieving the suitable data and responding to data queries. In the other words, in case, we show the all of allocated execution plans for responding to the query with S set, each member qep that belongs to S set has cost(qep) that this cost includes the time of processing and input/output. The purpose of each optimization algorithm is finding a member like qep_0 which belongs to S set, so that [3]:

$$cost(qep_0) = min_{qep \in S} cost(qep) \quad (1)$$

The execution plan for responding to query is the sequel of algebra relational operators applied on the database relations, and produces the necessary response to that query. Among the present relational operators, processing and optimizing the join operators which are displayed by symbol ∞ are difficult operations. Basically, join operator considers two relations as input and combines their tuples one by one on the basis of a definite criterion and produce a new relation as output. Since the join operator has associative and commutative features, the number of execution plans for responding to a query increases exponentially when the number of joins among relations increases. Moreover, database management system usually supports different methods of implementing a join operator for join processing and various kinds of indexes for achieving to relations, so that, these cases increase the necessary choices for responding to a query. Although all of the present execution plans for responding to a definite query, have similar outputs, but while generated inter-relation's cardinality aren't similar, thus generated execution plans have different costs. Thus selecting of suitable ordering for join execution affects on total cost. The problem of query optimizing which is called the problem of selecting suitable ordering for join operators' execution is NP-hard problem [4].

III. Learning Automata and Genetic Algorithms

Learning automata approach for learning involves determination of an optimal action from a set of allowable actions. It selects an action from its finite set of actions. The selected action serves as input to the environment which in turn emits a stochastic response from allowable responses. Statistically, environment response is dependent to automata action. Environment term includes a set of all external conditions and their effects on automata operation. For more information about learning automata, you can refer [18]. Learning automata have various applications such as: routing in communicative networks [20], image data compression [21], pattern recognition [22], processes scheduling in computer networks [23], queuing theory [24], accessing control on non-synchronic transmitting networks [24], assisting the instruction of neural networks [25], object partitioning [26] and finding optimal structure for neural networks [27]. For the query with n join operator, there are n! Execution plans. If we use learning automata for finding optimal execution plan, the automata will have n! Actions that the large number of actions reduces speed of convergence in automata. For this reason, object migration automata proposed by Oomen and Ma [18]. Genetic algorithms operate on basis of evolution idea and search optimal solution from among a large number of potential solutions in populations. In each generation, the best of them is selected and after mating, produces new childes. In this process, suitable people will remain with greater possibility for next generation [9]. For more information about genetic algorithms, you can refer to [28, 29].

IV. Proposed Hybrid Algorithm for Solving Join Ordering Problem

By combining genetic algorithms and learning automata and integrating gene, chromosome, actions and depth concepts, historical track of problem solving evolution is extracted efficiency and used in the search process. The major feature of hybrid algorithm is it's resistance versus nominal changes of responses. In other words, there is a flexible balance between efficiency of genetic algorithm, resistance of learning automata in hybrid algorithm. Generation, penalty and reward are some of features of hybrid algorithm. It has been explained in the following basic parameters of this algorithm.

A. Chromosome Coding

in proposed algorithm, unlike classical genetic algorithm, binary coding or natural permutation representations aren't used for chromosomes. Each chromosome is represented by learning automata of object migration kind, so that each of genes in chromosome is attributed to one of automata actions, and is placed in a definite depth of that action. In these automata, $\underline{\alpha} = \{\alpha_1, \alpha_2, \dots, \alpha_k\}$ is set of allowed actions of automata. These automata have k actions (the number of actions of these automata equals with the number of join operators). If number u join from given query is placed in the number m action, in this case, number u join will be m'th join of the query that will be executed.

$\underline{\phi} = \{\phi_1, \phi_2, \dots, \phi_{KN}\}$ Is set of states and N is memory depth for automata. The set of automata states are divided to k subsets $\{\phi_1, \phi_2, \dots, \phi_N\}, \{\phi_{N+1}, \phi_{N+2}, \dots, \phi_{2N}\}, \dots, \{\phi_{(K-1)N+1}, \phi_{(K-1)N+2}, \dots, \phi_{KN}\}$, and join operators are classified on the basis of this matter that in which state they are. If number u join of query is placed in the set $\{\phi_{(j-1)N+1}, \phi_{(j-1)N+2}, \dots, \phi_{jN}\}$, in this case, number u join will be n'th join that is executed. In a set of states of j action, $\phi_{(j-1)N+1}$ is called internal state and ϕ_{jN} is called boundary state. The join which has located in $\phi_{(j-1)N+1}$ is called more certainty and the join which has located in ϕ_{jN} is called less certainty. The join state is changed as a result of giving reward or penalty, and after producing several automata generations with genetic algorithm, we can achieve optimal permutation, and this is the best choice for the problem. If a join is located in boundary state of an action, giving penalty causes a change in

mmeybodi@aut.ac.ir

the action that join is located on it, and causes new permutations. Now consider the following query:

(A∞C) and (B∞C) and (C∞D) and (D∞E)

Each join operator has a clause for joining that is omitted for the simplicity of display, determines which tuples of joined relations emerge in the result relation. The above query is represented as graph in Fig.1. Capital letters are used for showing relations and P_i is used for show join operator.

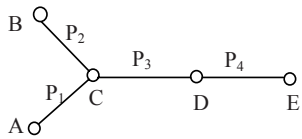


Fig. 1. An example of a query graph

We consider a set of join operators like p_1, p_2, p_3, p_4 to show permutation of join operator executions with object migration automata, based on Tsetlin automata. This automata has four actions {a_1, a_2, a_3, a_4} (the same number of query joins) and depth 5. A set of states like {1,6,11,16,21,26} are internal status and a set of states like {5,10,15,20,25,30} are boundary states of learning automata. At first, each of query joins is in the boundary state of related action. In hybrid algorithm, each of chromosome's genes equals with one automata action, so we can use these two words instead of each other. Learning automata (chromosome) has four actions (gene), and each action has five internal states. Suppose in the first permutation, the order of join operator executions will be join 3, join 2, join 1 and join 4 respectively. The way of representing execution order by object migration automata is shown in Fig.2. This matter is done on the basis of Tsetlin automata. At first, each of these joins is in the boundary state of related action.

B. Fitness function

In genetic algorithms, fitness function is the feature for surviving chromosomes. The purpose of searching the optimized order of query joins is finding permutation of join operators, so that total cost of query execution is minimized in this permutation. One important point in computing fitness function is the number of references to the disc.

So, we can define the fitness function of F for an execution plan like qep as follows:

$$F(qep) = \frac{1}{\text{The number of references to disk}} \qquad (2)$$

For computing the number of references to disc (the cost) of an execution plan, consider execution plan as a processing tree. The cost of each node as recursive form (down to up and right to left) is computing by adding the total number of achieved costs of the two child nodes, and needed cost for joining them in order to achieve the final result [7]. For example, we consider join R1∞R2:



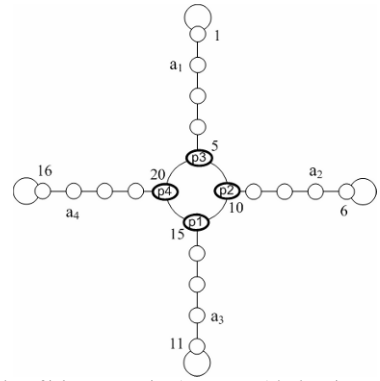


Fig. 2. Display of joins permutation (p_3, p_2, p_1, p_4) by learning automata based on Tsetlin automata connections

In this case, the cost of evaluation equals to following amounts:

$$C_{total} = C(R_1) + C(R_2) + C(R_1 \infty R_2) \qquad (3)$$

In which, $C(R_k)$ is the cost of achieving to child node, and is computed is follows:

$$C(R_k) := \begin{cases} 0 & \text{if } R_k \text{ is a base relation} \\ C(R_i \bowtie R_j) & \text{if } R_k = R_i \bowtie R_j \text{ is an intermediate result} \end{cases}$$

In a special manner, if R_1 and R_2 are both the base relations, the cost C_{Total} equals with $C(R_1 \infty R_2)$ and according to this matter that we have used nested loops for join operator implementation, so the computation cost of join operator will be same as $C(R_1 \infty R_2) = b_{R_1} + b_{R_2}$ and b_{R_k} is numbers of blocks of R_k relation.

C. Operators

Considering this that in hybrid algorithm, each chromosome is represented as learning automata; crossover and mutation operators are different from similar operators in simple genetic algorithms.

Selection Operator: The selection method used for this algorithm is roulette wheel [7].

Crossover Operator: In this operator, two parent chromosomes are selected and two genes i and j are selected randomly in one of the two parent chromosomes. Then these genes are selected in another parent. A set of genes with numbers between i and j are called crossover set. Then, genes which have same numbers replace with each other in two crossover set (for example, i gene from first crossover set replaces with the i gene from the second crossover set. i+1 gene from first crossover set replaces with the i+1 gene from the second crossover set, and so on). Two new chromosomes are produced in this way which are so-called the children of two automata parents. In continue the pseudo code of this operator is represented in Fig.3. Since, n chromosome (automata) is used in this algorithm, and each automata has its own special characteristics (states, actions and objects like

mmeybodi@aut.ac.ir

each action), we represent these features by automata name and point separator for more readability of pseudo code. For example, for showing the join state of u from i automata, LAi.State(u) has been used. In the aforementioned algorithm, $cost_i$(LA1) is the cost (the number of reference to disc) for joining the i'th action of first learning automata.

```
Procedure Crossover ( LA1, LA2 )
  Generate two random numbers r1 and r2 between 1 to n
  r1 = Random *n; r2 = Random *n;
  r1 = Min(r1, r2 ), r2 = Max(r1, r2 )
  For i = r1 to r2 do
    If (cost_i( LA1) < cost_i( LA2) ) then
      j = Action of LA2 where
      LA2.Action( j ).Object = LA1.Action( i ).Object;
      Swap( LA2.Action ( i ).Object, LA2.Action( j ).Object );
    Else
      j = Action of LA1 where
      LA1.Action( j ).Object = LA2.Action( i ).Object;
      Swap( LA1.Action( i ).Object , LA1.Action( j ).Object );
    EndIf
  End For
End Crossover
```

Fig. 3. Pseudo code of crossover operator

Mutation Operator: For executing this operator, we can use different methods which are suitable for work with permutations. For example in swap mutation, two actions (genes) from one automata (chromosome) are selected randomly and replaced with each other. The pseudo code of this operator is represented in Fig.4.

```
Procedure Mutation (LA)
    i = Random *n; j = Random *n;
   Swap(LA.Action( i ).Object , LA.Action( j ).Object);
End Mutation
```

Fig. 4. Pseudo code of mutation operator

Penalty and Reward Operator: In each chromosome, evaluating the fitness rate of a gene which is selected randomly, penalty or reward is given to that gene. As a result of giving penalty or reward to the gene, the depth of it changes. Fig. 5 shows the pseudo code of reward operator.

```
Procedure Reward( LA, u )
    If ( LA.State( u )-1) mod N <> 0 then
        Dec ( LA.State( u ));
    End If
End Reward
```

Fig. 5. Pseudo code of reward operator

For example, in automata like Tsetlin connections, if p_2 join be in states set {6,7,8,9,10}, and the cost for p_2 join in the second action will be less than average join costs of chromosome, reward will be given to this join and it's Certainty will be increased and moves toward the internal states of that action. If p_2 join be in the internal state, and take reward, will remain in that state. If the join cost be more than the average join costs in chromosome, so the state of this join isn't suitable and is given penalty. Pseudo code of penalty operator is shown in Fig. 6. The manner of join move occurs in two different ways and is shown below.

1) The join be in a state except boundary state: giving penalty reduces the certainty of the join and moves toward the external states of that action
2) The join be in a boundary state: in this manner, we find a join from query, so that if we change place of two join in execution plan, the cost will decrease more. In this case, if found join be in a boundary state, the place of two joins is replaced, otherwise, at first, the determined join is transmitted into its boundary state, and then replacement takes place. The Pseudo code of hybrid algorithm is shown in Fig.7.

```
Procedure Penalize( LA, u )
    If (LA.State(u)) mod N <> 0 then
        Inc(LA.State(u));
    Else
        BestCost = ∞ ;
        for U = 1 to n do
          Create QEP  LA′ from LA by swapping u and U
          If  cost_i( LA′) < BestError then
              BestCost = cost_i( LA′);
              BestJoin = U;
          End If
        End for
        LA.State(BestJoin) = LA.Action( BestJoin)*N;
        LA.State(u) = LA.Action(u)*N;
        Swap(LA.State(u),LA.State(BestJoin));
    End If
End Penalize
```

Fig. 6. Pseudo code of penalty operator

```
Function JoinOrdering(Query)
   //n=Number of Joins
   Create the initial population LA1 … LAn;
   EvalFitness();
   While ( Not (StopCondition)) do
      NewLA1=NewLA2= LA with minimum Value of Cost;
      For i = 2 to n do
         Select LA1 ;
         Select LA2 ;
         If ( Random > 0.9 ) then
            Crossover ( LA1, LA2 );
         End If
         If (Random > 0.6 ) then
            Mutation ( LA1 ); Mutation ( LA2 );
         End If
         NewLA_{i+1} = LA1;
         NewLA_{i+2} = LA2;
         i=i+2;
      End For
      For i = 0 to n do
         LAi = NewLAi;
         u = Random *n;
         If (cost_u( LAi) <MeanCost ) then
            Reward(LAi , u );
         Else
            Penalize(LAi , u );
         End If
      End For
      EvalFitness();
   End While
End JoinOrdering
```

Fig. 7. The Pseudo code of hybrid algorithm for solving join ordering problem in database queries

mmeybodi@aut.ac.ir

V. Experiment Results

In this part, experiment results done by learning automata (LA) and genetic (GA) and hybrid (GALA) algorithms are presented. The results show that hybrid algorithm has dominance over the methods of learning automata and genetic algorithm.

Fig.8 shows the results of hybrid algorithm based on Tsetlin automata in comparison with learning automata and genetic algorithm. In the following diagrams, the vertical axis shows the average cost of executing plans that resulted by each algorithm and horizontal axis shows the number of joins in queries.

The experiment results show that hybrid algorithm has better and suitable results in comparison with genetic algorithm, and the cost of executing plans with hybrid algorithm for a definite number of joins is less than genetic algorithm, but the results of hybrid algorithm based on Tsetlin automata in comparison with learning automata don't have appropriate improvement, and mostly results of these two algorithm are close to each other and sometimes hybrid algorithm had better efficiency. Figures 9, 10 and 11 respectively shows the results of hybrid algorithm based on Krinisky, Krylov and Ommen automata in comparison with genetic algorithm and learning automata. The experiments show that the dominance of hybrid algorithm over other methods, in other words the cost of execution plans obtained by hybrid algorithm based on Krinsky and Krylov and Oomen automata has been less than other algorithms in all states.

Comparing the results of hybrid algorithms with each other show the dominance of hybrid algorithm based on Krinsky automata over other. This matter is shown in Fig.12. So, we can say that from among algorithms, hybrid algorithm based on Krinsky is the most suitable way for solving join ordering problem in database queries. Finally Fig.13 shows the Comparison of averaged cost obtained from hybrid algorithms based on different Automata depth.

VI. Conclusion

In this paper, a hybrid evolutionary algorithm has been proposed for solving the optimization of join ordering problem in database queries. This algorithm uses two methods of genetic algorithm and learning automata synchronically for searching the states space of problem. It has been showed in this paper that by synchronic use of learning automata and genetic algorithms in searching process, the speed of finding an answer has been accelerated and prevented from getting stuck in local minimums. The results of experiments show that hybrid algorithm has dominance over the methods of genetic algorithm and learning automata.

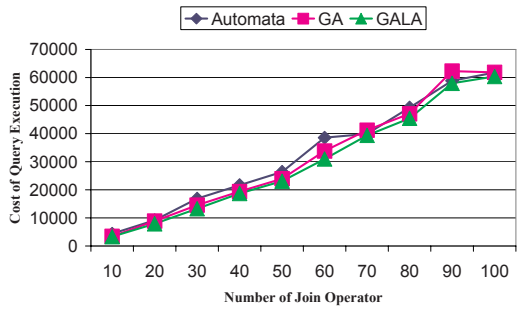


Fig 8: Comparison of averaged cost obtained from hybrid algorithm and learning automata based on Tsetline and genetic algorithm.

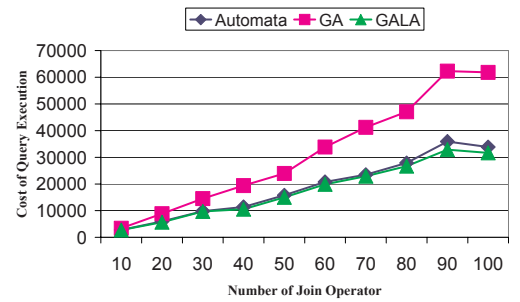


Fig 9: Comparison of averaged cost obtained from hybrid algorithm and learning automata based on Krinsky and genetic algorithm.

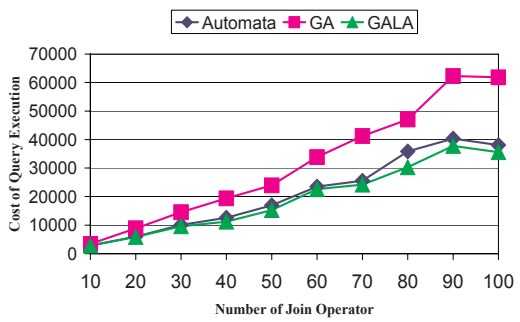


Fig 10: Comparison of averaged cost obtained from hybrid algorithm and learning automata based on Krylov and genetic algorithm.

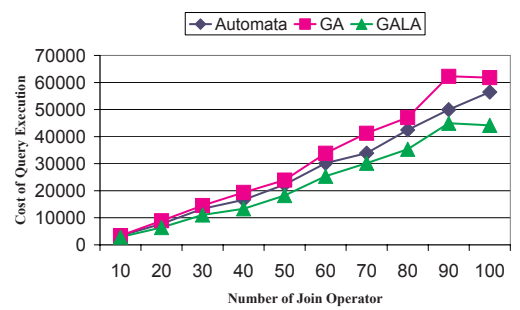


Fig 11: Comparison of averaged cost obtained from hybrid algorithm and learning automata based on Oomen and genetic algorithm.

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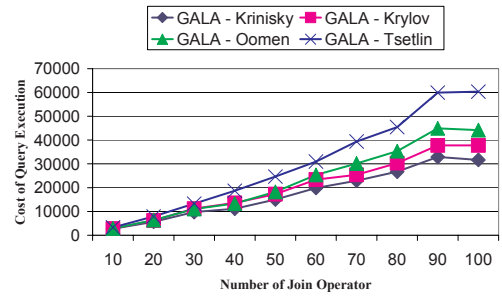


Fig 12: Comparison of averaged cost obtained from hybrid algorithms based on different Automata.

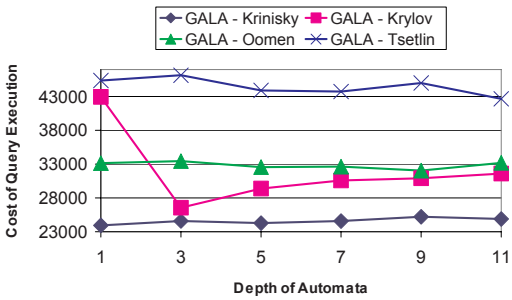


Fig 13: Comparison of averaged cost obtained from hybrid algorithms based on different Automata depth.

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mmeybodi@aut.ac.ir

Cooperative Training Initiative: An Assessment of Reciprocal Relationships Between Universities and Industry in Providing Professional Development in ICT

Khalid S. Rabayah,
Faculty of IT, Arab American University-Jenin, West Bank, Palestine
Badie Sartawi,
Computer Science Department, Alquds University, Jerusalem, Palestine

Abstract - **This paper presents the outcome of evaluating a training initiative which targets fresh graduates in Information and Communication Technology disciplines. It describes a contemporary training model where industry and academia join efforts to upgrade the students' qualifications prior to entering the labor market.**

The paper presents the experience carried out by a group of researchers investigated the effect of the training initiative targeted over 450 young engineering and computer science students throughout West-Bank and Gaza. The researchers traced the trainees endeavors in searching for jobs, using various methods, ranges from focus group meetings, to individual interviews, and questionnaires filling.

The purposed model promotes the involvement of the young engineers with authentic and up-to-date industrial experience, enables the build up of their practical framework and encourages their entrepreneurial growth. Of all the trainees surveyed, the overwhelming majority of the trainees felt that they gained valuable knowledge and experience in their field of training. The majority thought that the subjects of the training were vital and in demand by the market.

the model presented in this paper describes a modern training framework, where students receive practical training in third party institute that works in full coordination between universities and industry. The model relaxes universities from the pressure of constantly modifying their curricula to the market needs. It also helps qualifying large number of ICT students and graduates that over-sized the ICT industry capacity, especially in the developing countries.

I. INTRODUCTION

There are growing concerns that universities are not responding fast enough to the business and technology changes that have redefined the role of information systems in today's businesses and organizations. Debating this issue is sometimes linked to the fundamental question of the main mission of universities. Some people argue that the mission of universities is career education not job training, as debated, by Bill Readings in his book [1].

Some people believe that curricula have to balance theoretical with industrial knowledge, [2]. For technology-rich subjects like ICT, many believe that the rapid pace of technological innovation demands professionals to have state-of-the-art technical knowledge [3,4]. Others believe advances in computer technology lessen the need for technical expertise [5]. According to [6,7,8,9], ICT professionals who possesses sufficient human relations, management training, and can communicate effectively remain scarce and vital resource for the development of viable economies.

ICT education has been criticized as incapable of producing qualified, employable professionals [10,11], and universities have been accused for teaching obsolete technologies and irrelevant computer programming languages [12]. These accusations suggest an "expectation gap" between the need of industry and the academic preparation of those intended to satisfy them, as formulated by Galliers [13]. Many studies [14,15,16,17], reported industry dissatisfaction with what ICT graduates are taught. Business leaders were also concerned that information technology graduates are coming out of higher education without the right skills.

Despite publications by professional association such as the Data Processing Management Association (DPMA), and the Association for Computing Machinery (ACM), [18] of curricular guides (DPMA1981, 1985, 1990,), there appears to be insufficient inputs from industry about the quality and relevance of ICT education. In such a rapidly evolving field, there is a need to continuously and systematically examine the fit between the skills and knowledge possessed by ICT graduates and the requirements of industry.

Industry and universities must work together to close the expectation gap in graduates credentials. Some people demand universities to place more emphasis on the integration of technologies, applications, and systems. They also demand businesses to send consistent messages to universities about

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 255–260.
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mmeybodi@aut.ac.ir

their expectations while recognizing that the mission of university is career education, not job training. There are many views and methodologies suggesting bridging the gap between industry and academia references 19 through 24 are some examples [19-24].

In addition to the challenge posed by vast pace of technological advancement, major ICT vendors has intervened in the education and training processes, which adds to the complication of the issue. Some of them have gone far to the extent of establishing academic institutions; CISCO academy, Oracle University, and Microsoft academy, are only few examples. The so-called vender specific training courses pose challenge to traditional programs. In many cases their graduates have better employment chances than that of academic institutions. Educational specialists acknowledge the value of industrial certifications, and encourage students to pursue them as they see necessary. However, they do not believe that academic credit should be offered for completion of such certifications, nor for training exclusively designed to prepare for these certifications [18]. Most certifications are practice-oriented and has minimum focus on the underlying theories and concepts. Additionally, many certifications are specific to a given vendor solutions and are very narrowly focused. They therefore usually do not meet the learning criteria identified by accreditation bodies [18].

II- DESCRIPTION OF THE INITIATIVE

The present initiative represents a competency building model that tries to fills the gaps of the pre-described training frameworks. It offers practical and up-to-date training to large number of students. The model allows students to receive practical training in third party institute that works in full coordination between universities and industry. The model relaxes universities from the pressure of constantly modifying their curricula to the market needs. It also helps qualifying large number of ICT students and graduates that over-sized the ICT industry capacity, especially in the developing countries.

The Centers of Excellence are designed to fulfill the initiative's key components, namely: (1) training toward IT certification through professional trainers and state-of-the-art curricula in partnerships with IT businesses; (2) providing career development services to help IT professionals find jobs; (3) providing loans to make high-level (expensive) training broadly accessible; and (4) developing business incubator services [19].

The training phase started with the funding and implementation of training programs focusing on establishing a base of certified professionals. The pilot training and certification exam projects were completed at five Palestinian universities: Al-Quds University in Jerusalem, An-Najah University in Nablus, Palestine Polytechnic University in Hebron and Arab American Universities in Jenin in the West Bank, and the Islamic University of Gaza.

The centers are located in the proximity of the university campuses to facilitate students and faculties interaction and access of their resources. They are open for the community too. Academia and businesses meet in the centers to develop training contents, environment and tools, towards enhancing graduates' competencies as demanded by businesses.

The initiative, we think, is a pragmatic training model for diverse stakeholders. From one side, businesses will not be overburdened in training hundreds of IT students in their premises; at the same time can align the contents to their needs. On the other side, the model relaxes academia from incorporating vender specific courses, therefore keeps their neutrality to concentrate on theoretical and conceptual subjects. Training contents are developed in tailor-made packages in cooperation with the industry, and made flexible to meet changing demands, and allow tracking of new areas identified by business needs which occurs at faster pace than academia can withstand. One strategic objective set by the Excellency centers is to upgrade staff skills in designing materials that incorporate new teaching technologies. Training also incorporates courses in technical training, business and communication skills.

III- RESEARCH METHODOLOGY

In performing this evaluation, the research team gathered data using a combination of techniques which was carried out in two phases. Phase one comprised of: (1) Review of key documents, files, and reports provided by ANERA, (2) Focus group meetings with beneficiaries, including university administrators, faculty members, students, and trainers, (3) Individual interviews with IT stakeholders; namely, Palestine IT Association (PITA), representing the majority of the private sector businesses, Palestine Information Communication Technology Incubator (PICTI), number of NGOs, and number of private sector IT firms. The team conducted 39 individual interviews with key stakeholders throughout the project, including information system managers and ICT practitioners (e.g. software developers) (10 interviews), professors, university presidents and ICT education practitioners (15 interviews), Business consultants and CEOs (8 interviews), ANERA management personal (5 interviews), and others.

The second phase involved mainly a quantitative assessment of the initiative. Questionnaire was developed and mailed to trainees and beneficiaries. The questionnaire contained a series of tasks and knowledge/skills inventories drawn from discussions in phase one, including: (1) assessment of training programs and their context, (2) effectiveness of training programs concerning teaching methodology, (3) effectiveness of training on trainees future career, (4) connection between training and employability, (5) number, quality, and relevance of training programs, and (6) effect of training on women. Two hundreds and fifty questionnaires were sent to trainees by email or fax. Eighty (32%) of the forms were completed some of them through telephone interviews.

IV-SURVEY ANALYSIS

Training projects were implemented at five different locations, directed towards creating a pool of certified developers and trainers in different software development fields. Software development platforms from major software vendors were chosen; Microsoft, Oracle, and Sun Microsystems. For complete list see table 1 below. 445 students were registered from the five hosting universities which accommodate academic programs in ICT such as computer science, information technology, information systems, and computer

mmeybodi@aut.ac.ir

engineering. The selection of trainees based on qualification of candidates, especially the students' seniority in their academic programs. Senior students are better in pursuing practical-oriented courses, as they have solid theoretical basis in computer programming, software engineering, database, and networking, among other subjects.

ANERA managed to secure the fund from donors, where the USAID is the main contributor. The training cost per trainees per training hour ranges between $3.0 to $6.0. Trainees paid only 20% of the total cost, which on the average cost them about $100 per course. Programs were executed in cooperation with the private sector, as shown by table 1 below.

TABLE I
SUMMARY OF TRAINING PROGRAM ACTIVITIES

Institution	No. of trainees	Programs	Industrial partner
Al-Quds Univ.	60	Java, Oracle, MSCD	ATS*
Al-Najah Univ.	60	Java, Oracle, MSCD	AMRA+
Polytechnic	60	Java, Oracle, MSCD	ATS
Arab American Univ.	100	Java. Oracle	ATS
Islamic Univ.	165	Java, Oracle, MSCE Animation	Sidata-Gaza

**ATS: Arab Technology Solutions: Software development firm*
+AMRA: ICT training firm
Sidata: Software development & training firm
MSCD: Microsoft System Certified Developer
MSCE: Microsoft System Certified Engineer

TABLE II
DETAILS OF THE DIFFERENT PROGRAMS IN RELATION TO LOCATION

Islamic University of Gaza –IUG-

Program	Participants	Training hours	Certification[1]	Employment[2]
Cartoon & Animation	60	162	Not applicable	80%
Oracle	45	168	4	70%
MSCD	27	154	8	70%
Java	18	80	4	65%

Polytechnic University -Hebron

Program	Participants	Training hours	Certification[1]	Employment[2]
Oracle	24	160	14	70%
MSCD+	20	347	1	70%
Java	12	80	4	65%

Arab American University-Jenin –AAUJ-

Program	Participants	Training hours	Certification[1]	Employment[2]
Oracle (OCP)	20	128	2	60%
Oracle (DPA)	40	120	0	60%
Java	40	80	0	55%

Alquds university –Jerusalem

Program	Participants	Training hours	Certification[1]	Employment[2]
Oracle	20	120	5	80%
MSCD+	18	200	2	85%
Java	20	80	2	70%

Al-Najah University

Program	Participants	Training hours	Certification[1]	Employment[2]
Oracle	17	160	0	70%
MSCD	22	200	3	60%
Java	15	80	2	60%

[1]: number of students obtained international certification in their training field.
[2]: percentage of employed students after training, as reported by the university

In addition to the IT technical training, students also received training in business, interpersonal, and communication skills. They were also encouraged to work in teams and to practice in real-world projects.

The success of the training programs, as reported by the questionnaire results, varied from one site to another. Some of the findings reported by the questionnaire are summarized in the table below:

Trainees' Academic Background

Computer science	59%
Engineering (computer, electrical, telecom)	9%
Management information systems	22%
Others	10%

Gender Participation

Male trainees	80%
Female trainees	20%

Employment Status

Unemployed trainees	65%
Employed trainees	35%

Course Completion

Completed the program (% of registered trainees)	90%
Quit the course before completion (first quarter)	10%

International certification Exam

Did not sit for certification exam	83%
Sat for the certification exam	17%
% of the above who passed the exam	65%

70% of the trainees had no prior experience in IT technical training, being either fresh graduates or students, with pure academic background. This is to show that the training they have received is the main source of enhancing their practical experience. Most of the trainees were attracted by the low cost of the program and the fact that in their previous experience as students they had no time for IT training because other priorities were too pressing.

A-Impact of Training on Job Search

The majority of the trainees (70%), as the training records in the five hosting universities have shown, did not sit for the international certification exam, partly due to financial reasons. Certification exam(s) cost between 100 to 400 USD, depending on the subject, and some of them required more than one exam sessions. Instead, the trainees have opted for the University/Training Center examination. Many of them saw this as sufficient certification to seek a job or to improve their employment position. The local certification, as one

mmeybodi@aut.ac.ir

Islamic University of Gaza manager puts it, is acceptable locally and internationally. Examples were given of graduates working with such certificates in USA, UK, and some Gulf States. Some of them reported that the reason for not sitting for the international exam is their desire to work in development and not in training field.

65% of the trainees were unemployed at the time of training, and found the training programs valuable in their hunt for better jobs. 50% of the trainees who were unemployed acquired jobs after the training and certification (local or international) and the training was the main reason for the appointment. The remaining of those who found jobs reported that training was not the main reason for finding a job but that it helped. This points to a sound correlation between the completion of the training programs and the employability of graduates. A summary of the questionnaire results is listed in the table 3:

TABLE III
IMPACT OF TRAINING ON EMPLOYMENT OF TRAINEES

Category	**No. trainees**	**Percentage**	**Remark**
Trainees unemployed prior to training	52[1]	65%	% of the total number of trainees (80)[2]
Positive impact in search for job	32	61%	% unemployed trainees (52)
No impact	18	34%	% unemployed trainees (52)
No answer	2	4%	% unemployed trainees (52)
Employed since training	27	52%	% unemployed trainees (52)
Certification (local or international) direct reason for employment	10	19%	% unemployed trainees (52)
Certification(local or international) helped in employment	17	33%	% unemployed trainees (52)

[1]: unemployed students when the training programs started, and responded to questionnaire
[2]:all graduates that the evaluators could reach

The 17% of the total number who managed to do the international certification exam, 65% of them succeeded and rewarded the professional certification in various training subjects.

The majority of the employed people at the time of training (15% of the total number of training) reported that the programs had a positive effect on their work, which is confirmed by their employers. Interviews showed that their understanding, analysis capabilities and their hands-on-experience in using new ICT technologies were far improved, when compared to fresh graduates without a similar training.
The success rate of the training programs and their encouraging impact are mainly referred to the selection of vital training subjects that are needed by the Palestinian ICT sector, especially in software development. The training approach, also played a role as sufficient number of training hours were allocated, and the reliance on real and practical implementations. Technical training skills were mixed with business, communication and interpersonal skills, as students had to work in teams, also contributed to the program success.

Many of the business mangers we interviewed were interested in hiring the trainees, since they were faster in doing real valuable work from the beginning of the seizing of their posts. In contrary, fresh graduates, as they articulated , need at least few months to get acquainted with the state-of-the-art technology, improve their technical, and interpersonal skills before they can produce. Some other manager were attracted by the up-to-date technological, and practical experience in addition to the graduates academic education. The hands-on experience the graduates gained in vital IT subjects, like software development, attracted employers, in contrary to what is taught in academic programs, which is, as one business CEO puts it, focuses mainly on obsolete technologies.

B-Impact of project on IT sector
ANERA has targeted trainees in different locations across the West Bank and Gaza with the objective of enhancing the level of proficiency among IT workers on the national level. It has helped upgrade the skills of Palestinian IT professionals in local software industry, government, financial, education, health and social services sectors.

445 professionals were trained among them 115 Java, 135 Oracle, and 75 MCSD, in addition to the unique animation program. The number of people who received international certification through the program is estimated to be more than 50, which is about 12% of the total number of trainees. Those certified people are assets to the IT community, as they can potentially work as trainers, to generate more qualified professionals. Many of those we were able to contact are enjoying prestigious, well paid positions in the software industry or in local training centers, others were able to establish their own businesses.

TABLE IV
EFFECT OF TRAINING ON OFFICIAL CERTIFICATION

	Oracle	MCSD	Java
Before ANERA project	5	1	1
After ANERA project	45	14	7

V- CHALLENGES AND OBSTACLES

The model adopted to carry out the training has based on collaboration between the private sector and the training center, which is located within local universities. The model was not successful in all places, and that has to do with the ambiguity of whose role is to train; university or private sector. The private sector sees universities as competitors in the training fields. The private sector considers training one of its business areas, while universities tend to think that it is part of the teaching and instructing process that belongs to its mainstream role. Another friction point created because the majority of trainees are university students, and they will be trained within the university campus. In the training model the centers' role was restricted to providing the training materials

mmeybodi@aut.ac.ir

and the venue for the application for the certification examination, which was not always acceptable by universities.

Both sides looked at the training program as a source of revenue generation, as the training cost is totally provided by ANERA. They do not sufficiently appreciate the value of having certified IT professionals available. In some cases, as with Amra (training firm) -An-Najah University and to a lesser degree Sidata- IUG, the relationship between the university and the private sector were not cooperative. An-Najah university refused to allow the private sector to train its students. They argue that they have their own trainers, and well capable of providing the training. They only reached an agreement when they both share training responsibilities and revenues.

But in the case of ATS and AAUJ, Al-Quds University and PPU, the relationship was of mutual benefit, and appreciation. ATS's main business line was software development and not training. ATS invested in the trainees and the universities, because the mutual benefits to both sides were clearly defined.

One of the main challenges in the course of implementing the training program was to convince students to sit for the international certification exam. The culture of technical training and certification were not recognized by the majority of university students. It was easier to convince students to join the training programs, but not to encourage them to work hard, and to sit for the certification exam. This explains the low fraction of certification rewarding. Some trainees referred this to the fact that training was proceeded in parallel to their university load and their agendas are packed with other priorities.

The training programs were started in September 2000, during one of the most difficult periods for the Palestinian territories: the eruption of the second uprising, which has had a highly negative impact on all levels of Palestinian life. The political, social, and economic situation during the implementation of the IT initiative has posed great challenges. The situation had negative effects on the development of the IT initiative in several ways: (1) many people could not travel to attend training sessions, (2) some people were not able to meet the minimal financial obligations of the training, (3) people, including IT professionals, left the country in seek for safe heaven and better job opportunities elsewhere, and (4) a number of training programs have taken longer than expected due to inability of students to attend classes or inability of instructors for some courses to come from abroad. These conditions were fully recognized by the organizing body, ANRA, therefore it had to provide incentives in form of financial support, and continuous encouragement to help students complete the courses.

VI-CONCLUSION

The paper suggests a practical solution in plugging the gap between the industry needs and the qualifications of the university graduates. The initiative incorporates the establishment of training centers with strong connections to the ICT industry, and which have very flexible curricula policy to tailor contents to changes in business world. The training center will work to provide ICT students with practical skills directed to practical solutions. The proposed solution is characterized by flexibility, high level of adaptation and tracking to industry changes, and at the same time maintains neutrality and originality of academic programs.

The preliminary result of the initiative comprised of four ICT training centers in the proximity of Palestinian universities in both Gaza and the West Bank is largely encouraging. The survey conducted has shown that acquired skills greatly assisted fresh graduates seizing quality jobs in the industry and the public sector alike, especially when compared to those who did have the chance for a similar training opportunity.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Contribution to the Research and Education of Innovation Engineering and New Product Development at the University

Kristina Zgodavova*, Lubomir Lengyel, Ljudmil A. Golemanov
Alexander Dubcek University of Trencin, Trencin 91150 Trencin, Slovak Republik
*Email: zgodavova@tnuni.sk

***Abstract*-The paper is presenting theory and methods applied in research and education activities in the field of innovative engineering and new product development at the Alexander Dubcek University of Trencin. Its criteria function is: "Conception originality and perfection of mechatronic components details". The functions of mechatronic products are developed on the base of a system quality paradigm, complexity theory, duality of research-education process, latest knowledge gained in the field of mechatronic products design and eManagement of mechatronic product quality by means of a new combined procedures called QKS based on QFD (Akao, 1990), Kansei Engineering (Nagamachi, 1995) and Stage-Gate model (Cooper, 1990). The paper is giving and example of dual solution of a new course concept: "Innovation Engineering and New Product Development" applying the Project Based Learning and Glossary Based Learning. Our outcomes are aiming at the specialists engaged in mechatronic products quality, but could be used also as a guideline for students and wide public during development of any products. The paper is based on outcomes gained in the research project MS SR VEGA 1-2120/05 "Research of Principles and Concepts of Future Organization e-Management Development" and KEGA 3-4121-06 "Web Portal of Tools, Methods and Case Studies of Quality Management".**

***Keywords*-**theory of mechatronics, complexity theory, process duality, innovation engineering, new mechatronic product development

I. INTRODUCTION

We have always had the vision to be competitive based on:
"*Conception originality and perfection of mechatronic components details*".

Achieving competitiveness and reasonable price of new mechatronic products on the global market needs to consider and apply effectively the approach towards the processes and product design, product realization, customers' supply with products, towards the product use and its recycling. The tasks to be fulfilled in this field are voluminous and arduous as to the expertise, time and resources [1]. Depending on rationality of their solutions is prosperity and survival of organizations involved in the mechatronic products. The core of the problems stems in the conditions for the production competitiveness that should be introduced in the manufacturing organization in advance. And the same time there is a need to respect and overcome internal and external changes in the surrounding and time. The main factors in developing mechatronic production especially are qualified and skilled people with their knowledge and abilities to foresee factors influencing the future success of the company.

In the paper our theoretical and methodological outcomes describing possible solutions to development of mechatronic products functions are described. We have divided our paper into following parts:

- System paradigm and complexity of the mechatronic products quality;
- Duality of research and education processes and proposed conception of the course "Innovation Engineering and New Product Development" while employing the methods Problem Based Learning (PBL) and Glossary Based Learning (GBL);

New QKS procedure: Quality Function Deployment (QFD) [13], Kansei Engineering (KE) [17] and Stage-Gate (SG) model [21] with example of new product development: Mechatronic Perpendicular Measurement Device (PMD).

II. SYSTEM PARADIGM AND COMPLEXITY OF NEW MECHATRONIC PRODUCTION QUALITY

A complex production can be represented by: mechatronic systems, robots etc.

Mechatronics is centered on mechanics, electronics, control engineering, computing, molecular engineering (from nanochemistry and biology) which, combined, make possible the generation of simpler, more economical, reliable and versatile systems.

Definition used by the EEC[1]:

Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes [4].

The purpose of this interdisciplinary engineering field is the study of automata from an engineering perspective and serves the purposes of controlling advanced hybrid systems. The word itself is a portmanteau of "Mechanics" and "Electronics" [3].

For the purpose of our paper the term production means the process and results of target-oriented activities, i.e. production processes and their final results – products.

[1] EEC – European Economic Community

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 261–267.
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mmeybodi@aut.ac.ir

Quality of production can be discussed as a complex quality of production or separately as a quality of processes and quality of products.

ISO 9000:2005 describes quality as DEGree [DEG] to which a Set of INHerent CHARacteristics [INHCHAR] fulfils REQuirement [REQ]. This cannot be taken for a description of quality in the strict sense of the word but can be used as instruction as to how QUANtify given QUALity by MEASure MAPing [DEG]: [INHCHAR] <|STR|> [REQCHAR], where the stochastic EQUivalence [EQU] denoted here in after by <STR> is determined by Space Time Resolution [STR] [25].

When researching, in our works we adhere to the philosophical – Hegel's explanation of quality, and we define quality of mechatronic product by adjusting the context of definition [5] and [25] as follows:

Mechatronic product quality is a complex of properties, symptoms and exceptionalities of mechatronic production manifested in the given surrounding and time by symptomatic functions.

The symptomatic mechatronic production functions are the relations with the given environment and in specific time. Their existence requires mechanical components, electrical engineering and computer technologies.

We are presenting and emphasizing these facts for they represent the system approach towards the quality paradigm developed and applied by us for mechatronic production. The model of system approach is shown in Fig. 1.

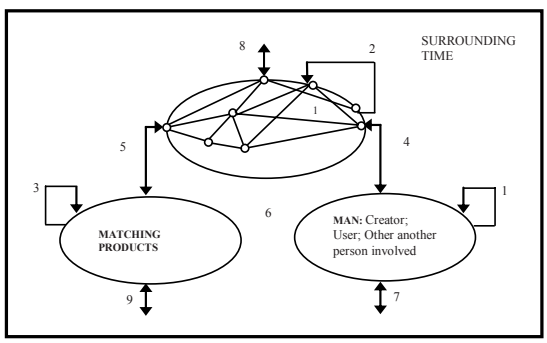


Fig. 1 To understand the system approach of quality paradigm and its complexity

1 – Programs on development control, utilization of mechatronic production, and common operation of the production examined in given surrounding and time
2 – Program on production development
3 – Program of co-operation of related productions
4 –Relations between the production examined and a man
5 – Correlation between production examined and production related
6 – Correlation between a man and productions that are involved with the production examined/assessed
7 – Relations between a man, environment and time
8 – Correlation between the production investigated and the environment and the time influence
9 – Correlations of co-operating productions between the environment and time
10 – Internal structure of the production examined – its elements and links
SURROUNDING – all significant facts together
TIME – calendar and procedural

Thus, designing, realizing and offering some products of a certain quality present a complex and undoubtedly dominant human activity that forms conditions for human existence.

What does complexity really mean? What does it mean to be "complex"?

Dictionaries can be hardly helpful because there are a lot of different definitions and ideas.

According Horgan [6] in his essay "From complexity to perplexity" published in Scientific American, mentions 31 various definitions of complexity and of a unified concept.

IEEE dictionary [7] defines complexity as: "Complexity is a status a system or component attains, though the status is hard to understand and verify".

Evans [8] stated the so-called inherent definition of complexity: "Complexity is the state of a system or of system component complicatedness, determined by such factors as the number and intricacy of interconnections, number and intricacy of conditional branches, depth of research, and the data structures type.

According to [9]: "Complexity is the property of a real world system that is manifested in the inability of any formalism being adequate to capture all its properties. It requires that we find distinctly different ways of interacting with systems. Distinctly different in the sense that when we make successful models, the formal systems needed to describe each distinct aspects are not derivable from each other".

For our needs to examine the complexity of mechatronic production quality the definition reads:

The mechatronic production quality complexity presents an intricacy of the sum of its properties, peculiarities, and from these following symptomatic functions in the given environment and given time.

The notion of complexity can be also explained as "system of systems", and then to consider in this appearing numerousness of binary decisions. Per Fig. 1 in question there are 10 intricate bonds with a varying number of properties, containing numerous chronologically appearing binary decisions. If we, just for illustrative purposes, again use the number of 10, we arrive to intricacy with number of 2100 combinations of binary decisions.

Presently, at disposal is the developed theory of complexity and generally recognized is the statement of Professor John Lye from Brock University, Canada: "The skillful use of the resources of the art form in evoking depth and complexity is known as quality" [10].

Lectured at prominent universities commonly is the algebraic complexity theory, and well known is, e.g., also the ASQ[2] Discussion Board: Complexity Theory in Quality [11] and, moreover, the NESCI[3] Institute, focusing on complex systems.

[2] ASQ – American Association for Quality
[3] NESCI - New England Complex System Institute

mmeybodi@aut.ac.ir

Based on the above outlined review, as well as on the quality definition we have used, it follows that complexity of quality of production as of a whole is that, which will gradually combine technical, natural and social sciences.

Extent and impact of thus construed complexity upon any fields of human activities is generally accepted, as attested to in the saying of Stephen Hawkins in January, 2000 [12]:

„*I think the next century will be the century of complexity*".

AECPD[4] definition of Engineering:

Engineering is the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination, design and forecast their behavior under specific operating conditions, and respect an intended function, economics of operation and safety to life and property [24].

Innovation engineering starts with idea, pure research, new product development and design, and ends with product testing, verification, validation and launch.

Respecting complexity concerns also process research approaches in the field of production quality that necessitates exploring also duality of research-education processes and developing creativity and innovation of students of mechatronic engineering course at the university.

III. Duality of Research and Education Process in the Domain of Mechatronic Production

Duality of processes should be examined always within all groups of processes selected. Of basic significance is recognition of mutual influence of research and education activities. The duality of research and education processes is the stability of their propinquity in designing mechatronic production, in its realization, as well as offering the production to the customer. Mutual correlation function comprising selected characteristics of partial processes can be considered the degree of stability.

When we designed the concept of the study subject "Innovation Engineering and New Product Development" we were using the syllabus that we have based and developed on our own knowledge and expertise and on a number of various resources:

1) Successful solutions for mechatronic production.

2) Utilization of the best techniques in our own research-education processes.

3) Critical examination of applications and developing own models and measuring degrees to examine duality and research, education quality enhancement and its results.

4) Meeting conditions described in directives and recommendations given by accreditation and other commissions.

5) Amending strategies of development in research and educational processes considering the needs and capabilities of all parties involved.

6) Developing the syllabus and schedule of the in-service university staff and students´ training aimed at an intensive enhancing of research and education processes to achieve excellent results.

7) Continuous electronic monitoring of adopted degrees of duality and quality. Research and education processes management while applying principles and observing rules in the future organization's e-Management, and e-Learning.

Based on partial utilization of this scheme we have chosen development of quality functions of the new mechatronic products using methods: QFD, Kansei Engineering and Stage-Gate model as the example of the course: Innovation Engineering and New Product Development (Fig. 2).

Information sheet for the subject "Innovation Engineering and New Product Development" is demonstrated in (Tab. 1). The subject is covered by 36 lecture hours and 49 seminars hours with 7 credits (ECTS[5]).

During seminars involved in the course "Innovation Engineering and New Product Development" Project Based Learning Method (PBL) is employed emphasizing the mastering main terminology using Glossary Based Learning (GBL) method. Example of mechatronic measurement device "Mechatronic Perpendicular Device" (MPD) invented at the Technical University of Kosice, Slovakia is introduced.

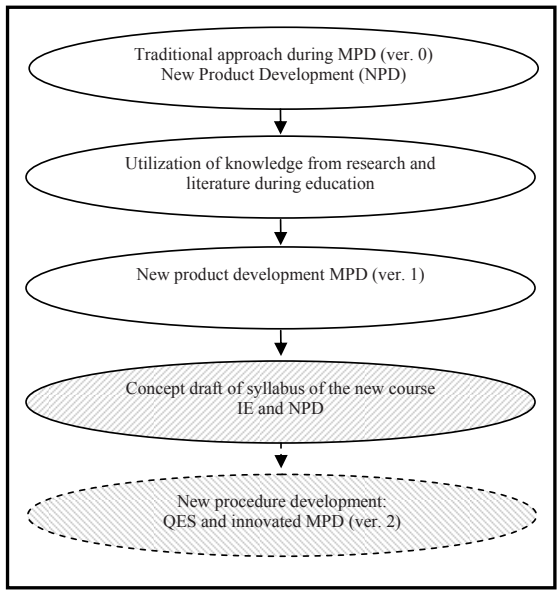


Fig. 2 To the issue of duality of the research and education process

TABLE I
Innovation Engineering and New Product Development Course Curricula

[4] American Engineers' Council for Professional Development

[5] ECTS – European Credit Transfer System

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No	Glossary Based Learning Lectures	Problem Based Learning seminars
1	Objectives, scope and methods employed in teaching the innovation engineering and new product development	Methods and workshop assessment
2	Basic theory of production quality, innovation engineering and new product development and launching	Variants of possible topics of course projects
3	Survey and prognoses on production needs, production portfolio management	Gathering resources for the project
4	Technology and knowledge management	Accepting and starting the mechatronic project Example of Mechatronic Perpendicular device
5	Innovation models: QFD, Kansei Engineering, Stage-Gate model	Project Glossary Development
6	QFD – Quality Function Development New production functions and parameters	Needs and requirements of product determination Example of Mechatronic Perpendicular Device and problem solving
7	Stage-Gate model	Designing and setting objectives, matching and specific production functions
8	Kansei Engineering	Production components and module catalogue development
9	Measuring, monitoring and quality control	Preparation of blueprint documentation concept using AUTO CAD
10	Verification and 0-series of production	Production process and sub process structure design
11	New product launch, process and product correction, settling of production	Projects presentation and evaluation
12	Production service and liquidation	Projects presentation and evaluation
13	Evolution perspectives of objective functions of artificial intelligence and new technologies	Projects presentation and evaluation

IV. New Product Development Using QFD, Kansei Engineering and Stage-Gate Model

The concept design phase is the most critical for the success of any product. Several methods have been developed to support designers in each activity of concept design.

A. Quality Function Deployment

Quality Function Deployment (QFD) was developed in Japan in the late 1960s by Professors Shigeru Mizuno and Yoji Akao [13]. Quality Function Deployment provides a logical structure for translating the "Voice of the Customer" (VoC) [14] into specific, measurable product and process characteristics. It helps teams to design a product that customers actually want, handle trade-offs between competing or conflicting requirements, and position the product against its competition. As a result, QFD can significantly reduce engineering changes, design cycles, start-up costs and warranty claims.

Adjusted QFD process according [15] and [2] includes following phase sequence: Customer/interested parties perceptions of quality – Voice of Customer; Product planning; Product design; Process planning; Production planning; Products usage and liquidation planning [2].

Each phase or "motivation" represents a more specific aspect of requirements put on the product. Binary relations amongst elements are assessed for each phase. Positioned into the following matrix are only the most important aspects of each phase. Detailed QFD resolution is presented e.g. [14].

B. Kansei Engineering

Kansei Engineering (KE) is a method for translating feelings and impressions into product parameters. The method was invented in the 1970s by Professor Mitsuo Nagamachi. He recognized that companies often want to assess the customer's impression of their products. Kansei Engineering can "measure" the feelings and shows the relationship to certain product properties. In consequence, products can be designed to bring forward the intended feeling. Because of the dual nature of customers' needs (functional and emotional) product concept design have to address both products' physical quality and products' emotional quality.

The success that has invested KE is mainly due to its systematic procedure by which it is possible to evaluate the "quantitative" relationships between emotions and feelings of users and product elements [17], [18]. An efficient procedure to assess product's emotional quality by KE can be schematized into five phases [19]:

1. Exploration of the semantic dimension
2. Exploration of the physical properties dimension
3. Synthesis
4. Analysis
5. Product development strategy

A new approach for identifying total quality elements in concept design phase is here proposed. It aims at defining a structured process of continuous innovation starting from both

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functional and emotional users' needs. This approach is divided into two phases [20]:

1) The first phase aims at exploration and identification of users' needs. Innovation is represented by parallel identification of physical-functional-declared quality elements and emotional-kansei quality elements:

- Identification of Must-be (M), One-dimensional (O), Attractive (A) quality elements Kano model [16];
- Identification of emotional quality elements;
- Concept generation: a set of virtual prototypes using a CAD system;

2) The second phase aims at selecting the optimal concept, at validating the choice through a confirmatory step and at establishing a continuous step by step innovation process:

- Concept evaluation. The collected data are statistically analyzed;
- Optimal concept selection and confirmatory session;
- Innovation: the collected information and the collaborative process between designers and users.

C. *Stage – Gate Model*

Among most wide-spread models used during development of new products belongs so called Stage-gate model (phase and gates process), which was created according method established in NASA in 1960. Basic idea of this model are phases with defined inputs and outputs, every phase ends with decision about continuing in project, what contributes to the actions standardization. This model was adapted beside USA army also by companies as Hewlett Packard and others. Major demerit of the first generation model was that it dealt only with design phase, not with complete innovation process, which represents the way from idea creation to its introduction into the market. Following research led to the creation of second and third generation models. Second generation model is segregating innovation process to five phases. In the end of every phase is a gate, which decides about continuing or stoppage of the project. Decision is made by interdisciplinary team of specialists. Model integrates technological and market perspective. Its advantage is in simplification of communication between research teams, so as between top management members and also between research teams and top management [21].

D. *Combined method*

Using combined procedure: QFD, Kansei Engineering and Stage-Gate model and an example of new product development: Mechatronic Perpendicular Measurement Device (PMD) [22] is illustrated in Tab. 2.

Example of detail application of combined QKS procedure: QFD, Kansei Engineering and Stage – Gate model during new product development and during education of university course: Innovation Engineering and New Product Development are presented in the paper [23].

V. CONCLUSION

Complexity of the mechatronic and other comprehensive product quality development is so wide-ranging that we have only outlined it, and some information given in this summary has already been mentioned above:

1) New mechatronic product development may be purposefully modeled and meaningfully simulated on the basis of quality systemic paradigm and theory of complexity. The QKS procedure: Quality Function Deployment, Kansei Engineering, Stage-Gate model is also available.

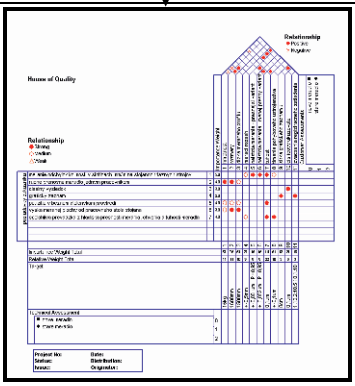
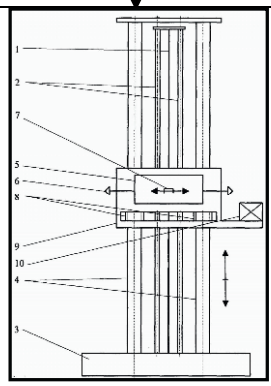
2) The process of new mechatronic product development is at the university as well in an organization of dual nature having the form of internal and external management of performance of ongoing processes. The synergic effect of their operation depends on mastering the complexity of quality, which must be conscientiously respected.

3) Further development and improvement of quality functions is significantly conditioned by transforming correspondence/non-correspondence management and requirements to be met in managing the development of new and progressive effects of the mechatronic product and consequential quality demands. Innovation can be successful only to the extent in which the invention, intuition; creativity and complexity theory application are joint.

4) The development of new mechatronic products should have not only complex but also dynamic properties based on dynamic programming. In all engineering activities the changes in development of production components properties are considered.

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TABLE II
QKS PROCEDURE

Quality Function Deployment	Kansei Engineering	Stage-Gate Model
[**1.QKS**] 0. Customer/ interested parties perceptions of quality – Voice of Customer [14]		
		[**2.QKS**] Invention: Mechatronic Perpendicular Measuring Device [22]
		[**3.QKS**] 1. Gate: Ideas evaluation
		[**4.QKS**] 1. Stage: Preliminary evaluation
		[**5.QKS**] 2. Gate: Detailed ideas evaluation
[**6.QKS**] 1. Product planning		
	[**7.QKS**] 1. Exploration and identification of semantic dimension of users' needs	
	[**8.QKS**] 2. Exploration of the physical properties dimension	
	[**9.QKS**] 3. Synthesis	
	[**10.QKS**] 4. Analysis: Using multivariate statistical methods	
	[**11.QKS**] 5. Product development strategy	
		[**12.QKS**] 2. Stage: Product definition
		[**13.QKS**] 3. Gate: Decision about development
[**14.QKS**] 2. Product design		
		[**15.QKS**] 3.Stage: Development
[**16.QKS**] 3. Process planning		
[**17.QKS**] 4. Production planning		
[**18.QKS**] Exploitation and liquidation planning		
		[**19.QKS**] 4. Gate: Decision about testing
		[**20.QKS**] 4. Stage: Testing
		[**21.QKS**] 5. Gate: Decision about market introduction
		[**22.QKS**] 5. Stage: Commercialization
 Mechatronic Perpendicular Measuring Device QFD matrix	 Mechatronic Perpendicular Measuring Device Kansei Engineering drawing	 Realized Mechatronic Perpendicular Measuring Device
Evaluation and feedback		

1 – String; 2- Tightening stand; 3 – Base; 4 – Leading stand; 5 – Measuring carriage; 6 – Bifacial measuring touch; 7 – Induction sensors; 8 - Turning nuts; 9 – Platform of the measuring carriage and of electromotor; 10 – Electromotor with friction drives

mmeybodi@aut.ac.ir

ACKNOWLEDGMENT

Our acknowledgement goes to Technical University in Kosice, Faculty of Mechanical Engineering, Department of Instrument and Biomedical Engineering which markedly contributed in development of the Mechatronic Perpendicularity Measuring Device.

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mmeybodi@aut.ac.ir

Our Stations for Teaching Programmable Devices

K. M. Noga, M. Radwanski
Gdynia Maritime University
Morska str. 83
81-225 Gdynia, Poland

***Abstract*-W The article presents examples of application for programmable devices to control several simple models of physical objects. During the digital logic classes students from Faculty of Marine Electrical Engineering become familiar with designing digital control systems. During laboratory sessions students create control systems for models and realize particular assignments with application of programmable logic devices.**

I. Introduction

Programmable Logic Devices (PLD) are one of the fastest developing technologies in electronics. Loading a program into the system changes its inner structure, thus electrical characteristics and realized functions. When compared to conventional TTL technology and CMOS integrated digital circuits, programmable devices stand out because of the greater flexibility and much easier physical realization when necessary is processing large amount of data or complex logic function.

Producers of programmable devices offer free-of-charge computer software, which provides a complete design environment that easily adapts to specific design needs, ensures easy design entry, fast processing, and straightforward device programming. This software is a fully integrated, architecture-independent package for designing logic with various programmable logic devices and offers a full spectrum of logic design capabilities: four design entry methods for hierarchical designs. Methods of entering a project are as follows: descriptive – project description should be entered by using one of the hardware description languages, graphical – logic scheme or automatic graph is entered as well as time functions.

In the Department of Ship Automation of the Maritime Academy in Gdynia during laboratory students use the following hardware description languages: VHDL (Very-high-speed Integrated Circuits Hardware Description Language) and Verilog for devices from Altera [1] and VHDL and ABEL (Advanced Boolean Expression Language) for devices from Xilinx [2]. The software that students use is Altera MAX+Plus II and QUARTUS II [1, 3, 4, 5] and Xilinx Webpack ISE [2]. Special starter kits provided with additional components and control systems for mobile models were either purchased or self-constructed in the Department of Ship Automation. During laboratory each student should become familiar with the environment used in preparation of control programs as well as student should be able to implement in the complex programmable logic device (CPLD) or the field programmable gate array (FPGA) systems a control program for particular model, prepared outside laboratory sessions. A set of commands to be performed by a model is defined by a teacher. During six laboratory hours a student should activate combinational and sequential control, as well as present control algorithm, functional and time analysis and a report.

In this article we present the models that are used to study programmable devices and already elaborated starter kits.

II. Programmable Logic Devices Control

Control of physical objects by logic devices significantly differs from control by microprocessor systems. Standardized device description languages reduce the differences. This has been achieved through introducing conventional program structure such as conditional instructions, loops or procedures [5, 6]. PLD based control system is presented in the Fig. 1. The most important advantage of the programmable devices is large number of I/O pins and strictly defined time of data processing. All modern programmable devices are provided with interface, the most popular being JTAG, which is used to programming without a necessity to disconnect the device from final system.

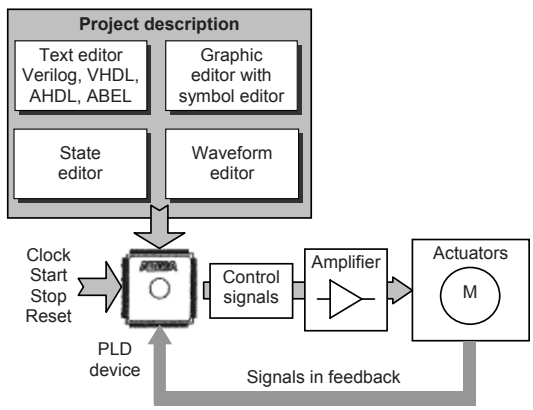


Fig. 1. PLD based control

III. Examples of Models

A. Model of a Crane

The least complex model adjusted to control through logic devices is the model of a crane (Fig. 2). The model is provided with three motors that allow tower rotation of about 350°, movement of the lift truck along the outrigger and hook lifting/lowering. Model control is based on generating adequate

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 268–273.
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combination of six control signals that control activation and course direction of a single motor. To unload the programmable device, electromechanical relays with additional amplification of control coil current were applied.



Fig. 2. Laboratory station with the model of a crane

The programmable device operates under the kit ZL1PLD [7], which allows activate the Altera system CPLD EPM7128SLC84-15, as well as Xilinx XC95108. The components that generate input signals in the ZL1PLD are two hexadecimal switches and two 2-state switches, whereas output conditions are indicated by two 7-segment displays and 9 LEDs.

Controlling the model of a crane with combinational system is based on generating control signals on the basis of the state of available input components in the ZL1PLD, for example selection of a motor can depend upon condition of hexadecimal switch, while direction of a single motor can be selected through 2-state switches. Sequential control is based on generation of a sequence of output signals corresponding with a sequence of movements of each element in the model assumed in advance. For model is not equipped with sensors of extreme position of movable elements, it is necessary to include a safety device that would unconditionally stop operation of all movable components and to determine the initial model condition before executing the program.

B. Model of a Hoisting Winch

A model of a hoisting winch (Fig. 3) is based on actual technical solution in three-gear double direction hoisting winch. At the Gdynia Maritime University, available is also a control system of hoisting winch constructed with net of transmitters, with programmable logic controllers (PLC) and with application of digital TTL integrated circuits [8]. Additionally in Department of Ship Automation, activated was an Altera starter kit with the CPLD system (Fig. 4) that allows complete control of the hoisting winch. The kit can be also used to implement any project having 16 logic inputs of voltage 12 V or 5 V, and up to 32 logic outputs, where 16 of them are placed on two 7-segment displays, whereas another 16 outputs are provided with current amplifier allowing control of different executing systems. Logic state of the outputs is also shown at LEDs.

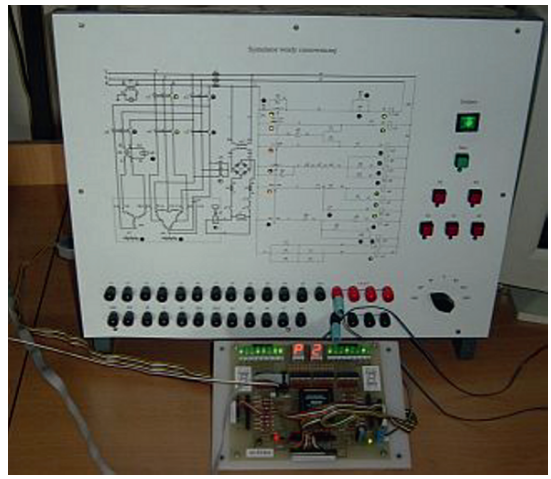


Fig. 3. Laboratory station with the model of a hoisting winch

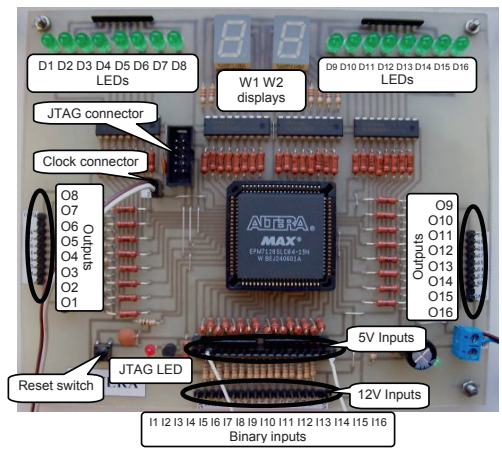


Fig. 4. Starter kit controlling the model of a hoisting winch

Control of the model is based on simulation of supply contractors of motor windings enclosure (enclosing successive windings, switching over delta-star, crossing phase windings) and controlling time relays based on any subset of input signals in regulating unit and thermal safety devices, and overcurrent protection of motors. In the model, condition of contractors and relays is displayed on LEDs. Time effects in the programmable systems can be simulated using counters clocked from external generator. Control system implemented in the CPLD can be

mmeybodi@aut.ac.ir

both combinational and sequential. It is impossible if control system is based on network of relays or standard digital circuits.

A student task is to design a program allowing combinational or sequential model control. Moreover, a student needs to perform analysis, diagnosis and further introduce corrections in the programs including erroneous control.

C. The Model of an Excavator

A laboratory station, which allows control of an excavator model with utilization of VHDL [5, 6] was constructed in Department of Ship Automation. The station consists of a PC with installed WebPack software, ZL11PRG-M programming device [7], and another starter kit independently elaborated in Department of Ship Automation (Fig. 5) with control system based on XC95108 device by Xilinx as well as controlled object, which is excavator model. The programming device is connected to PC parallel port and to port JTAG in starter kit. The model consists of a chassis, a turret and an excavator's arm. In the chassis located are two direct-current motors responsible for chain drive. Another two direct-current motors are located in the turret. One of them secures the turret rotation, while the other movement of the lever arm. The system allows combinational or sequential model control. The object is able to move forward and backward and turn left or right as well as rotate the turret and put in motion the excavator's arm. Combinational control is based on the movement of the model to states assigned with eight external switches. Each motor is controlled by two switches. One of them is responsible for enclosure of supply, while the second switch for changing direction of the motor's rotation. Whereas sequential control is about the model executing programmed sequence of movements. Main limitation of the station is low capacity of memory for program's coding (limited to 2400 logic gates and 108 user inputs/outputs). The system ensures invertibility of the motors voltage biases, thus two-direction operation. It also ensures feedback through position sensors that detect extreme position points of the turret. Control of the object is realized through twelve signals transmitted from the CPLD system. Eight of the signals are responsible for motors' control, two for each motor. Another four signals collect information from position sensors. All output signals are transmitted in parallel from 25-terminal connector, thus control each movable element. Sequential control is possible due to time measurement. The timing clock is built on the basis of integrated circuit NE555. Additionally, two position sensors were built in the excavator to ensure the feedback. Its task is to limit turret rotation of 360° and therefore prevent rotation of the feeder of motor in the excavator arm thus prevent its failure. The feedback was realized through relay located in the chassis and a magnet affixed to the rotating turret. The station allows for simultaneous work of several motors and sudden polarization changes. Due to separation of system's supply and application of filtering capacitors the load has no effect on the systems' operation.

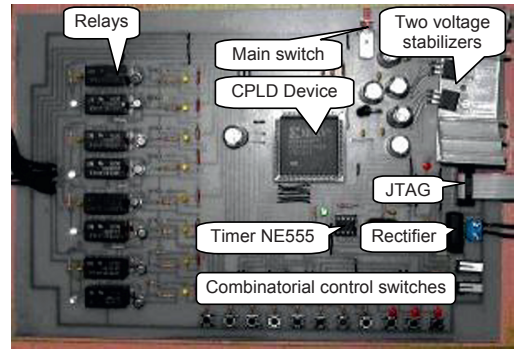


Fig. 5. Starter kit for the excavator model control

Schematic diagram of the developed starter system is presented on Fig. 6. The system consists of supply unit and the unit realizing control. In order to secure the system CPLD from disturbances occurring at the moment of connecting the model's motors, the supply is divided into two circuits. The first circuit provides voltage on integrated circuit NE555, serving as clock, and on the CPLD. The second circuit supplies the load. Supply of the switching station was realized by using integrated circuits L78S05 (constant voltage regulators) with current input limitation up to 2 A, and output voltage up to 5 V. In addition the system is provided with a security switch.

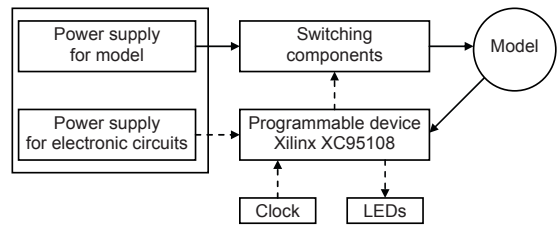


Fig. 6. Schematic diagram of the starter kit

Within the program of laboratory the students become familiar with exemplary combinational and sequential programs that control excavator's movement. For example students learn a program allowing combinational (manual) control of the model by switches, to which functions were already assigned at the stage of programming. Condition to be met in order to use manual control is stopping sequential program by using a START/STOP switch. Whereas sequential control is realized automatically once the system is activated. The program simulates situation in which the model must perform with a shovel, gathering action at the three remote points. After a single gathering action the model returns to the initial position and begins damping movement. Fig. 7 presents exemplary movement of the excavator.

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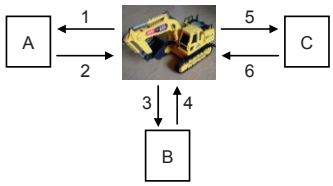


Fig. 7. Movement of the excavator model while performing exemplary program

Assignment for students in the laboratory is programming assigned sequence of the model movements. It is necessary to detect actual position and to set up required initial position of the turret. The problem to be should be solved during class hours, can be formulated as follows: program the system in a manner that allows the model to simulate gathering and dumping actions at 6 different points. The excavator model should at first gather cargo at one point and then move to the opposite point to leave it. The route is presented on the Fig. 8. The purpose of the assignment is to allow students to become familiar with all possibilities of sequential control; in this case a student needs to use each motor.

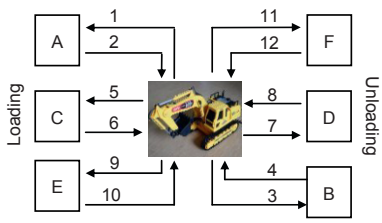


Fig. 8. Exemplary assignment for student's individual elaboration

D. Model of a Tank

Vehicle model – the US tank M1A2 Abrams was purchased on the Internet auction Allegro [9]. The model, of dimensions 410 x 155 x 145 mm, is equipped with six pairs of amortized wheels, a pair of drive wheels, which facilitate overcoming roadblocks. Each drive wheel is driven by separated electric motor. The wheels set in motion other wheels by crawler chain. Left and right crawler chain can move together forward and backward or each in different. This allows the tank to make right and left turns as well as rotation around its own axis. Two receiving antennas, located in the upper part of the tank, allow receiving control radio signals from a transmitter. In addition, a hole that allows load special synthetic nodules is placed in the middle of rotary turret, under a cover. The tank is able to fire the nodules in distance of about 25 m. The shooting mechanism operates on the principle of sudden air decompression that is pressed by small pump on the inside of the tank. Moreover, in the lower part of the tank two switches are located. Tri-position switch is used to decide about one of the three possible frequencies of receiver, of frequency band 27 MHz that is 27.095, 27.14 or 27.195 MHz. Whereas bi-position switch is used to activate a main supply source of the tank. This model is also provided with couple of front lights and couple of back lights. These are units controlling correctness of the model's operation as well as any symptoms of accumulator discharge. Educational kit Altera DE2, purchased at Terasic Technologies [10], and interface module with radio transmitter specially developed in Department of Ship Automation (Fig. 9) are applied to control the model. Block diagram of the interface for controlling the model is presented on the Fig. 10.

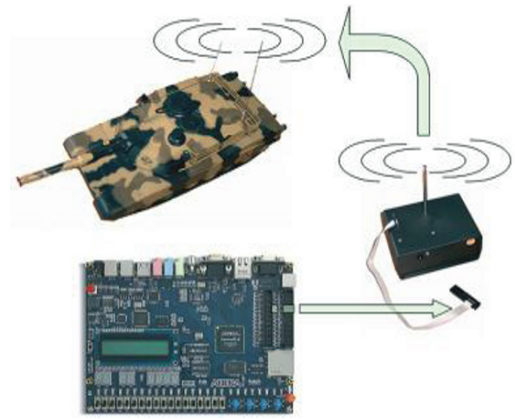


Fig. 9. Vehicle control diagram

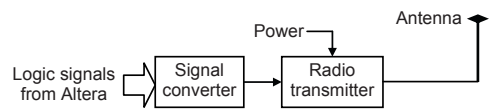


Fig. 10. Block scheme of the control interface

Altera DE2 board [11, 12] is connected to the interface module with a special cable. In turn, the interface module sends information for the vehicle control, which operates according to the program in VHDL language in the Quartus II environment [1, 3, 4, 5] for Cyclone II FPGA device. In sequential control, movements sequence is assumed by the programmer. Also possible is combinational control, which can be performed either with switches located at the board of Altera DE2 module, or due to serial interface RS-232 in the DE2 module. Exemplary route of the tank's movement with sequential control is presented on the Fig. 11.

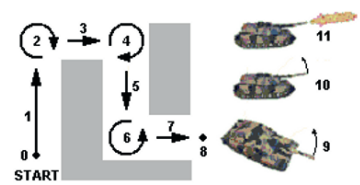


Fig. 11. Exemplary path of the tank movement with sequential control

The program's code, with type of control shown on the Fig. 11, is based on number of loops and conditional state-

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ments. Time countdown is based on incrementing adequate variable adjusted to the clock pulses of the processor, where applied was the clock of frequency 50 MHz. The second used variable is incremented after a single move of the controlled object. Dependently on the value of this variable the model executes adequate movement. Additionally eight 7-segment displays placed on the board of the module Altera DE2 were applied. The displays inform a user about execution of the assumed movement by the model. In the program code, the displays are defined as vectors of length 7 bites and each of these vectors controls a defined segment in a display. Moreover, outputs of the FPGA device, which control operation of the radio transmitter, are also defined as vectors.

According to the syllabus a student should become familiar with examples of control presented in a laboratory guide book before the class, and then individually develop control of vehicle movement along assigned route by teacher.

The laboratory station allows students to learn programming language VHDL in simple and pleasant fashion. General-purpose character of the educational kit Altera DE2 gives many possibilities to develop a laboratory stations.

E. A Robot – Human Robowisdom

The manufacturer of the robot is WooWee Ltd. Appearance of the robot, with indication on its movable elements, is presented on the Fig. 12 [13, 14, 15].

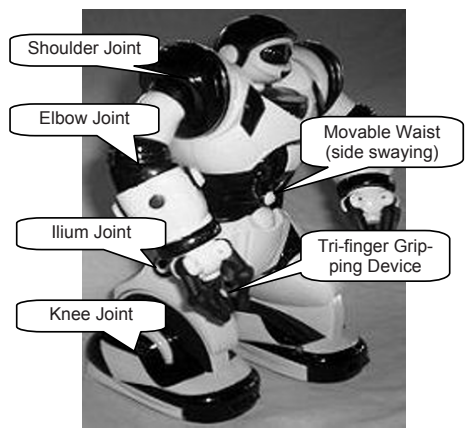


Fig. 12. Movable elements of the robot

Robowisdom is 35 cm tall and about 17 cm wide. Its body consists of series of hexagonal and triangular elements that give it the stability. The robot has four movable limbs and two tri-finger gripping devices. The arms are movable at elbow and shoulder parts, whereas the gripping devices are mounted with no wrists. Lower limbs are movable at two points – an ilium and a knee. At the tip of two legs are wide feet with installed storage batteries. Mainly because of such design, the centre of gravity of the robot is very low what allows movements with uncrossed arms or even moving the arms while walking without losing stability. Four supplying batteries of voltage 1.5 V allow constant work for 6 hours and additionally lower centre of the gravity. The robot consists of 10 built-in motors. Two motors put in motion robot's legs, another two allow right-left direction swaying moves, while six motors are responsible for moving robot's arms. Two motors are installed in shoulder joints, two in elbow joints and two are responsible for closing and opening tri-finger gripping devices of the robot. Robowisdom is able to bend waist left and right. The robot is also provided with six sensors. Two touch-sensors are located on each leg of the robot, in front and on the heel of the down-limbs. Each upper-limb is also provided with one sensor per hand. The sensors are installed at the ends of the fingers. Robowisdom is controlled through infrared, and infrared sensor receiving control signals is located in the robot's head. Carrier frequency of the infrared for Robowisdom equals 39.2 kHz.

The main disadvantage of the original Robowisdom control system with a remote controller is lack of possibility to program larger number of moves. After pressing the switch the robot was able to perform only one movement. For example the robot could move forward or raise the arm. Single activation of a function on a remote controller used to limit the robot to only one programmed movement.

In Department of Ship Automation of Gdynia Maritime University, educational kit Altera DE2 and VHDL programming language operating in Quartus II environment were applied in order to perform more complex sequence of movements. Software was prepared that allows control of the robot in two modes: sequential and combinational. In addition, voltaic separator was built that protects transmitter from negative effects of too high voltage of the control signal and therefore from destruction. Voltaic separator together with the system transmitting control signals was located in a separate casing. A diode transmitting control signal was incorporated on the outside of the casing.

Further development of the control system should not be a closed issue. It is possible to connect the educational kit Altera DE2 with the model through the interface RS-232. In this case virtual microprocessor Nios II should be developed and then implemented in the SOPC Builder environment and the NIOS IDE [1, 10] using the language C/C++. Infrared transmitter/receiver should be also developed. Fig. 13 presents schematic diagram of the solution.

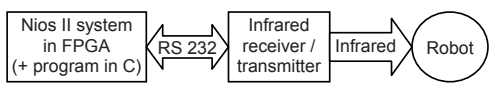


Fig. 13. Schematic diagram of control with interface RS232

Combinational control of the robot-human model is based on manually assigned orders, through switches located on the board of educational kit Altera DE2.

A combination circuit, designed in exemplary program included in laboratory instructions, is a switching circuit, used to transmit bivalent signals. Circuit input signals originate in switches, whereas output signals control the model of a robot. Additionally, the program signals actual condition of the circuit at LEDs and 7-segment indicators.

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For sequential control, the program was prepared that controls operation of the model in adequate order without manual intervention. Sequence and duration of the movements are defined at the program level. The whole process is performed in the loop. Two meters were used to measure duration of the single movement: Counter_1 and Counter_2, which allow raise overall sequence duration up to 96 seconds, and duration of the single movement up to 5.6 s. The principle of operation is based on counting rising edges of „clock" input that is 50 MHz and incrementing variable Counter_1. Incrementing of the second meter occurs when Counter_1 reaches value 120. Adequate value of Counter_2 causes corresponding connection of the outputs of the sequential circuit. The program also allows three-level adjustment of the sequence duration, through influencing magnitude of meter incrementing. Additionally the program allows neutralization or stopping control sequence. The Fig. 14 presents a block diagram of sequential control circuit.

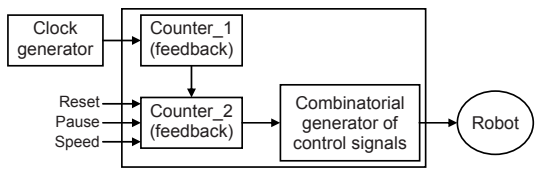


Fig. 14. Block diagram of the sequential control circuit

IV. CONCLUSIONS

Developed models are very popular among students and encourage students and teachers to increase their efforts as well as they diversify learning methods. Together with development of technology of programmable devices, the differences between programming these devices and circuits based on microprocessors become less visible. Presented laboratory stations with the models of an excavator, a human-robot and a tank were applied to realization of students' theses in Department of Ship Automation [16, 17, 18]. Such topics are becoming more and more popular. The laboratory stations allow students to become familiar with the principles of digital control, programming of PLD devices in different environments and applying different hardware description languages. The models presented in this article are also accessible on the Internet website dedicated to laboratory of digital logic [19].

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mmeybodi@aut.ac.ir

Implementation of Learning Objects Using J2ME: Putting into Practice the Concept of M-Learning in Brazil

Leandro Ramos de Oliveira and Roseclea Duarte Medina
IEEE Conference Publishing
Course of Computer Science,
Federal University of Santa Maria (UFSM),
Building 7 of Technology Center,
Camobi (RS-509), km 9
Santa Maria, RS, Brazil

***Abstract* - The following paper aims at presenting an alternative of implementation for a learning object that is used in a desktop environment. In order to be visualized and used by mobile devices users, putting into practice the idea of m-learning. The J2ME development platforms for mobile devices and mobile phone simulators have been used to carry out the work.**

I. Introduction

It is not recent the fact that computer science and education walk together, aiming at a greater spread of information, culture and knowledge, in an easy and fast way. Currently, however, by the advent of the mobile computation, a new concept for such union emerges, the m-Learning. Mobile learning is nothing more than the use of mobile devices such as cell phones, Personal Digital Assistants (PDAs) and smartphones, in the learning and teaching processes. This new paradigm may be applied not only in studying environments like schools and universities, but also in companies, for example, supporting training and qualification of the employees, or even contributing to the learning process of adults and elderly.

For the past years, when m-Learning had just begun, educators used computer science to develop learning objects, which are applications to spread educational contents in an interactive and effective way. Such objects are fully visualized in personal computers, however, most of them lack in resources, and some even become totally useless when accesses through mobile devices. Because of that, computer professionals have been trying to develop alternatives for the implementation of such objects, which allow them to be also visualized with all the available resources in mobile devices, enabling, in this way, the application of the m-Learning concept.

Throughout this paper it is intended to present an alternative for the implementation of a learning object to be used in desktop, which allows it to be visualized from a mobile device, and also to offer interaction possibilities for the user, giving the opportunity of a more dynamic and complete learning-teaching process. For such, it was used a development platform for mobile devices J2ME, of the Sun Microsystems corporation. Besides, due to the fact that few implementations with such intentions were developed, the validation of the developed object also presents a critical comparison between the object presented in the desktop and the one of the mobile device, with the objective, in this paper, to produce an analysis on the implementation and use of this object, highlighting its critical points in order to contribute for future papers.

Due to the fact that m-Learning is still recent, it is feasible to consider that the related scientific production is still in its initial process. Considering that, most of the papers developed up to now approaches the theoretical part of this new paradigm, and few bring implementation applications that fit it. This paper aims at presenting and impulse the development of applications that put into practice the matter of educational content production for mobile devices.

It is first presented a conceptual review on m-Learning. Highlighting questions of pattern, examples of applications and some related projects. It is also an objective to expose an analysis on the development of the platform for mobile devices J2ME, highlighting its architecture and topics of implementation. Besides that, it will be carried out a brief analysis of a learning object for desktop, as well as its visualization using a mobile devices simulator. To conclude, it will be presented the developed object, conclusions and future papers.

II. M-Learning

Education has always been one of the main worries and priorities for a society that searches for enrichment in all the aspects and, this way, the search for technological development is a great asset to reach such objectives. It was considering this context that, in the past few years, m-learning raised. M-Learning concept can be easily understood by the union of learning concepts and mobile devices. Thus, m-learning and all the learning process that is supported through

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 274–278.
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mmeybodi@aut.ac.ir

mobile devices, which have their own power source, and may be easily used wherever there is no access to physical networks [1]. It does imply the need of wireless networks use, since the device may offer the educational content stored in its hardware, enabling the mobile learning, although off-line.

One of the main problems related to the evolution of pieces of work using such paradigm is the fact that there is no concrete formulation on the pattern of the information access means. Due to the great number of available mobile phones with internet access, the production of content for such devices becomes limited because of variables like: cell phone manufacturer, operational system used on the apparatus, and for cell phones and smatphones, the phone server company. Many international organizations like Learning Technologies Standardization Committee (LTSC) of the IEEE, European Committee for Standardization (ECS) and the Subcommittee *36* of the first convention of the International Standardization Organization, in association with the International Electrotechnical Commission Committee (ISO/IEC JTC1 SC36), are examples of efforts for elaboration of standards for the development of contents to be visualized in mobile devices in general. Thus, in most of the results, what is obtained are URL visualizations able to be adapted for a good visualization in any other device, mobile or fixed. An example of that are the pieces of work developed by Mobile Web Initiative (MWI) that belongs to the W3C, and search for a definition of an only web, based on rules that, when followed by authors and developers, allow the resulting content to be visualized in any device [2].

Despite of the standardization lack, invest in the success of the m-Learning is valid and necessary. Because of the fact that we are dealing with resources like the internet, mobile devices and education, very spread and accepted by most of people, the available environment for the application of such concept is wide. We can highlight as an example of m-Learning: its application in groups of collaborative work, as a different way of teaching in schools and universities in relation to books and computers, in distance education, awareness campaigns, as support for employees' professional formation, among others. It is also possible to highlight projects that are developed all over the world, such as production of mobile applications by the City University of Hong Kong (CityU), focusing in making the Hong Kong students' learning more flexible, encouraging the use of technology [3]**.** Still, a project developed by Ericsson, aiming at evaluating the market acceptance of this new concept, through courses on m-Learning [4].

As seen in this section, despite the standardization lack , m-learning is a field that still has a lot to be explored, due to the great amount of application areas. In the next section, an alternative to the developers will be raised for them to produce contents to be used in these many areas. Subjects like offered resources, platform architecture and its evaluation in production of educational contents for mobile devices.

III. Development Platform J2ME

Java 2 Micro Edition (J2ME) is a platform totally projected to serve the needs of the developers of the mobile computation. Produced by Sun Microsystems, it is a subset of the pattern platform Java 2 Standard Edition (J2SE), which allows the production of applications for mobile devices like cell phones, PDAs, smartphones, among others. What those devices have in common is the fact that they have short processing capacity and low memory to support J2SE, used in desktops and servers, thus the need of a reduced version for the production of material for such devices. Besides that, it comprehends user interfaces, security models, communication protocols in nets and other functionalities that together constitute an environment of run-time Java optimized for the use of memory, processing and operations of input and output [5].

A. J2ME Platform Architecture

One of the challenges faced by Sun team, Java Community Process (JCP), while developing platform J2ME, was finding a way for the same application developed in J2ME, to be visualized in any of the many mobile devices available in the market. Because of the fact that such devices do not follow a hardware pattern, as the one followed in desktops, each manufacturer develops the device in accordance to his taste, what makes difficult generic applications.

The solution found by JCP was to separate the J2ME architecture into two parts:

--Configurations: that deals with the run-time environment (Java Run-Time Environment) and has a set of classes that work on each device, called core. Still, it is subdivided into two parts, one that works on devices with limited computational power, CLDC (Connected Limited Device Configuration), and another one that works on devices with higher computational power, CDC (Connected Device Configuration) [6];

--Profile: that consists of a set of classes that allow the developers to find the characteristics of a group of mobile devices and adapt their applications to them [6].

B. J2ME and development of educational applications

One of the main advantages of J2ME platform is the goal that all the developed application is accessible to any mobile device. This topic assures that a mobile learning object may be used independently of the user apparatus. For instance, if a cell phone is compatible with Java, it automatically converts the Java code and executes it, with no need to interpret and adapt it to the device architecture, what would restrict its functioning to certain phones.

Besides that, J2ME, in spite of being a simplified version of J2SE, presents good amount of resources that help the objects developer. Among those it is possible to highlight the fact that it is easy for the programmer to structure elements in the screen according to his will, defining the absolute positions, the facility to create images given by the use of the class Graphics and the easy understanding of the APIs, what

mmeybodi@aut.ac.ir

enables the easy and fast development of the applications.

All of these resources are valuable for the development of learning objects and were explored in the development of activities in this paper. In the next section the developed pieces of work will be described.

IV. Developed Activities

Based on the context displayed before, on the topic of m-Learning and the platform J2ME, it leads to the objective of this paper that is the development of a learning object for mobile devices. However, it is not only an implementation of any object. It is an adaptation of an object that is used in desktop environment and was projected for such, to be also accessed through mobile devices. It has been chosen, among the many educational objects in the repository of objects of the *Rede Interativa Virtual de Educação (RIVED)*, which is one of the most well-known programs for digital pedagogical contents in Brazil.

In the next sections it will be presented a general analysis on the chosen learning object, as well as an alternative for re-implementation of it for mobile devices, and a final analysis of the obtained results.

A. Analysis on the chosen learning object

For this paper, among many analyzed objects the chosen was "Roda Viva" (RIVED). It has as target public the students of the first grade of Elementary School, aims at introducing topics related to the physical movements of the body (force, mechanics and movement), to be discussed and debated in class. Besides that, since it is an introductory activity, the object is relatively simple, being only images transition and topics related to the theme [7]. Because of that, only HTML and XML resources were used, as well as an animation in Flash for images transition. It follows a figure of the way this object is visualized in a desktop environment at a 1152 x 864 pixels resolution.



Fig. 1. Visualization of the learning object *"Roda Viva"* in desktop environment.

Since this object was totally planned for a desktop environment, we can notice in Fig. 1 that it presents good visualization features. This way, the object keeps the totality of its resources, allowing the students to use good interaction.

B. Object visualization using simulators

An alternative to visualize the way the object "Roda Viva" would be displayed on a cell phone with internet access, for instance, not necessarily being implemented for such device, would be using a cell phone simulator. One example of simulator existent on the internet is the Ready.mobi, which uses pattern visualization tests in cell phones defined by the World Wide Web Consortium (W3C), in a partnership with mobility companies. This simulator generates a short report on the analyzed URL and simulates the visualization of it in some cell phone models.

Applying the simulator to the URL of the educational object, due to the fact that it had been implemented using HTML, XML and Flash, correctly following the patterns of web, the simulator Ready.mobi classified it as able to be visualized in cell phones. In their report, they graded it three, in a scale from one to five, highlighting what is correct in its HTML code and what can still be improved [8].

Since the simulator is based on the analysis of the topics of web patterns and good practices of development defined by W3C, it has as truth that if a URL is following the patterns, it also can be visualized in cell phones, what is not applied to the selected object, despite the obtained classification in the report. For learning objects, which are mostly used with Flash resources for the development of animations, games, among other activities that make easier the interaction and understanding of the content, they practically lose all the use due to the bad visualization that the resource in Flash presents when adapted to a smaller screen. Following, there is a visualization simulation of the object *"Roda Viva"* in the cell phones: Motorola v3i, Nokia N70 and Samsung z105, models available in the simulator report.

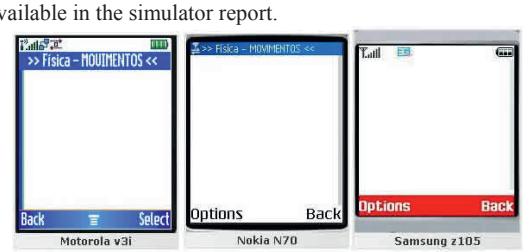


Fig. 2. Visualization of the Learning object *"Roda Viva"* in cell phone screens (Motorola v3i, Nokia N70 and Samsung z105).

Analyzing Fig. 2, we can perceive the total functionality loss of the learning object. In the devices Motorola v3i and Nokia N70, the only kept information of the object was the headline of the webpage, and in the Samsung z105 device, not even this was kept. The resource in Flash, presented by the object was totally lost, as well as the content, what nullifies its pedagogical use.

Based on these results, it is perceived that the majority of the learning objects available on the internet are not able to be accessed through mobile devices. In order to help on this

mmeybodi@aut.ac.ir

problem solution, in the next section we highlight an alternative to preserve the educational object functionality also when accessed from mobile devices.

C. Implementation of the adapted object for mobile devices

A second alternative to visualize the object *"Roda Viva"* in a mobile device, besides using simulators, would be implementing it taking into consideration the new environment since the beginning. For such, a development platform for mobile devices J2ME was used, as well as the Wireless Toolkit 2.5 for CLDC, both from Sun Microsystems.

Based on the previous analysis of the learning object, it was projected the re-implementation of it, trying to keep its characteristics, only adapting the necessary for good visualization and interaction of the user. Because of that, since the object is basically a continuous transition of images and texts, this same resource was developed, but now allowing the user to skip the image and text anytime he wants, pressing the right directional key in the phone, or back to the previous image or text, by pressing the left directional key. Besides that, the headline of activities and the bottom page notes were kept visible, only changing correspondent images and texts. This alternative allows using only one screen for the entire object, minimizing its size.

Below, an image of the object *"Roda Viva"* adapted to mobile devices using J2ME, being visualized in the simulator of the Wireless Toolkit 2.5 for CLDC.



Fig. 3. Alternative for implementation of the learning object *"Roda Viva"* for mobile devices.

Analyzing Fig. 3, we perceive that when the object is projected to be visualized in a mobile environment, it is possible to work the best way to overcome difficulties like screen size and implementation resource to be used. The implementation of the object *"Roda Viva"* in J2ME is relatively simple, since it does not require great animation resources, interactivity and complex images, what enables to keep its total functionality without making the object heavy to be accessed via wireless networks.

D. Results

Having the object *"Roda Viva"* available to be implemented to desktop environment and mobile devices, it is possible to set a parallel between the two versions. Following, two screens of the object visualized in a desktop and its respective implementation to mobile devices.

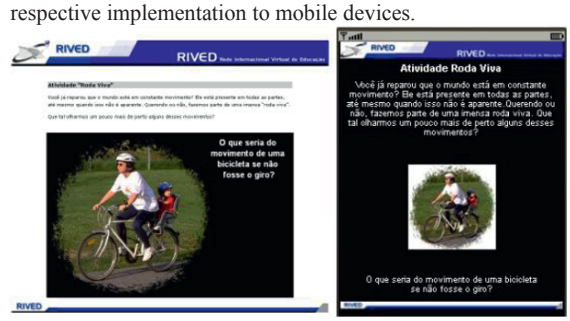


Fig. 4. Comparative of mobile and desktop environment. Example 1.

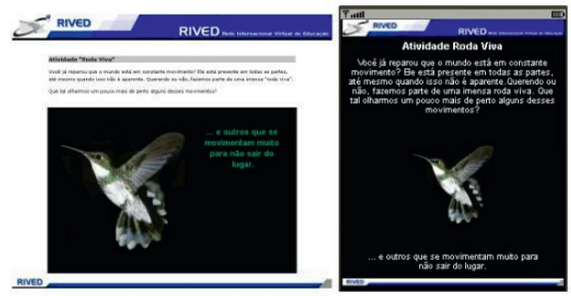


Fig. 5. Comparative of mobile and desktop environment. Example 2.

Analyzing Figures 4 and 5, it is possible to perceive that the main characteristics of the object are fully presented in both environments. Slight differences such as position of images and colors of the text are verified, however, they do not interfere in any of the learning objectives.

Another situation that is possible to be perceived is the quality difference in both environments. Because of the fact that we work with a smaller screen in mobile devices, it is inevitable the loss of image details due to the reduction they have to fit a smaller space. The distortion, mainly in the bottom page notes the image is noticed, in a mobile environment. A possible solution for this problem would be the production of alternative images that would keep the same characteristics of those produced for desktop, but with good visualization in a smaller screen.

The great difficulty in the development of contents for mobile devices is to make them accessible and possible to be presented in any device. Due to the great amount of apparatus in the market, with different architectures, hardware and systems, such adaptation of content is not an easy task. An example is the way the learning object is produced by this study is visualized in devices with different screens presented by the simulator.



Fig. 6. Visualization of the developed object at different resolutions.

The image on the left of Figure 6, presents a form of a bigger screen in the horizontal and smaller in the vertical,

mmeybodi@aut.ac.ir

what makes texts and images of the object to mix, losing its legibility and harmonious aesthetics. In the right image of Figure 6, besides mixing, the object also loses image quality, being the screen not a colored one.

V. CONCLUSIONS

Based on what was discussed throughout this paper, it is possible to perceive that the concept of m-Learning and its application are more and more diffused. The development of learning objects that fit mobile devices is valuable for educators that start having more options to promote education, as well as the professionals of information science, who are stimulated to develop pieces of work that may contribute for the development of this new technology. Besides, it is possible to perceive that the partnership between education and informatics might make easier the acceptance of mobile devices by the society, promoting a higher concentration of the papers related to the standardization of such devices. Facilitating, this way, any development of mobile applications, not only educational objects, since they are based on the same platform.

This paper attempts to present the current m-Learning state, highlighting questions of object implementation. However, the developed object was tested only in simulators and not in real devices. For future papers, it is intended to improve the implementation of such object to overcome the screen adjustment question, reported in the result analysis, and then, to test it in a real device. This way, it will be feasible to have a more concrete idea of the totality of the actually available resources, as well as the real difficulties found when you go from the virtual to the real.

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mmeybodi@aut.ac.ir

Using a Domain-Ontology and Semantic Search in an E-Learning Environment

Lothar Lemnitzer
Seminar für Sprachwissenschaft
University Tübingen, Germany

Kiril Simov
LML, IPP, Bulgarian Academy
of Sciences, Sofia, Bulgaria

Petya Osenova
LML, IPP, Bulgarian Academy
of Sciences, Sofia, Bulgaria

Eelco Mossel
University of Hamburg
Department of Informatics
Hamburg, Germany

Paola Monachesi
Utrecht University,
Uil-OTS,
the Netherlands

***Abstract* – The "Language Technology for eLearning" (LT4EL) project integrates semantic knowledge in a Learning Management System to enhance the management, distribution and especially the cross-lingual retrieval of learning material. One of the results achieved in the project is the construction of a language-independent domain-ontology with lexicons of eight languages linked to it. Learning objects of these languages have been annotated with concepts from this ontology. The ontology management system allows for semantic search which has been proven to be more effective than simple full text search for all languages of the project.**

I. Introduction

Given the huge amount of static and dynamic contents created for eLearning tasks, the major challenge for their wide use is to improve their accessibility within Learning Management Systems (LMS). The LT4eL project[1] tackles this problem by integrating semantic knowledge to enhance the management, distribution and retrieval of the learning material.

Several tools and techniques are under development within the Semantic Web initiative which can play a significant role also within eLearning. In particular, ontologies can be employed to query and navigate through the learning material and can thus improve the learning process.

Ontologies give the possibility to develop a more dynamic learning environment with better access to specific learning objects. Standard retrieval systems, which are usually employed within LMSs only consider the query terms, they do not take into account the systematic relationships between the concepts denoted by the queries and other concepts that might be relevant for the user. Ontologies, on the other hand, can be used as an instrument to express and exploit such relationships, which can improve the search results and allow for more sophisticated ways to navigate through the learning material. Furthermore, by linking the ontology to language specific lexicons, multilingual retrieval is enabled. We believe that the potential of ontologies in the area of multilingual retrieval is not sufficiently exploited yet. With our project we intend to make a contribution in this direction.

This paper discusses the role of the domain-specific ontology we have developed in the LT4EL project and of lexicons in several languages, i.e. the languages addressed in our project: English, German, Dutch, Polish, Portuguese, Romanian, Bulgarian and Czech, as well as the conceptual annotation of Learning Objects (LOs) for semantic search and retrieval of documents. The relation between the domain ontology and the learning objects is mediated by two kinds of information (or layers of information, as they are called in [2]): a) domain lexicons and b) concept annotation grammars. In our model the lexicons are based on the ontology, i.e. lexicons for the various languages have been compiled on the basis of this ontology, its concepts and relations. In a further step, the terms in the lexicons are mapped to grammar rules for the partial analysis of documents. These rules constitute annotation grammars which identify and annotate the ontological concepts in the texts.

We demonstrate the usefulness of this architecture – ontology, lexicons and annotated documents – for semantic search in a repository of learning objects. The superiority of the semantic search over simple text search has been proved in an evaluation experiment.

More generally, we believe that the use of ontologies and semantic search will facilitate the construction of user specific courses, will allow direct access of knowledge, improve the creation of personalized content and support decentralization and co-operation of content management.

The structure of the paper is as follows: in the next section we give an overview of the ontology creation process; we then present in detail the lexicon model that we use within the project; section 4 discusses the annotation of learning objects with concepts. In section 5 we present our semantic search engine, which has been evaluated against simple text search as described in section 6. The paper ends with some conclusions and an outline of future work.

[1] http://www.lt4el.eu/ – the LT4eL (Language Technology for eLearning) project is supported by the European Community under the Information Society and Media Directorate, Learning and Cultural Heritage Unit.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 279–284.
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mmeybodi@aut.ac.ir

II. The LT4eL Domain Ontology

The domain of our learning objects and the ontology we have developed within the LT4eL project is that of *computing*. The ontology covers topics like operating systems, application programs; document processing, WWW, websites, HTML, email, etc. It is used mainly to index the relevant learning objects and to facilitate semantic search and re-usability of learning objects.

The creation of the ontology can be summarised in the following steps: a)integration of keywords and b) formalisation. Later on new concepts (not represented by any keyword) have been added in order to improve the coverage of the domain.

The ontology is based on lexical items from all the languages of the project. The keywords were disambiguated and classified into the conceptual space of the domain and English translation equivalents were provided for them. After that, multiple natural language definitions for the concepts were collected by searching the WWW. One canonical definition was chosen for each concept. As examples of ambiguous keywords, take the terms *header* and *word*. They have more than one meaning in our domain. In the formalisation step definitions of the extracted concepts and relations have been formulated using OWL-DL (cf. [13]). The concepts were formalised in two separate steps. First, for each concept, an appropriate class in the domain ontology was created. The result of this step was an initial formal version of the ontology. Each concept was then mapped to synsets in the OntoWordNet version of Princeton WordNet (cf. [6], [7]), a version of WordNet which is mapped to the DOLCE ontology. The mapping was performed via the two main relations of *equality* and *hypernymy*. The first relation is between a class in the ontology and a synset in WordNet which (lexically) represents the same concept, while the second is a relation between a class in the ontology and a synset denoting a more general concept. Thus, the taxonomic part of the ontology was created. The connection of OntoWordNet to DOLCE allows an evaluation of the defined concepts with respect to meta-ontological properties as they are defined in the OntoClean approach (cf. [5]). The connection of the domain ontology with an upper ontology via WordNet facilitated the systematic search for conceptual gaps in the ontology which are due to the bottom-up approach through which it has been created.

Using this systematic approach, our ontology has been extended with additional concepts. We looked for a) missing concepts which relate to existing ones; for example, if a program has a creator, the concept for program *creator* is also added to the ontology, b) superconcepts of existing concepts; e.g. if the concept for *text editor* is in the ontology, then we added also the concept of *editor* – as a kind of program – to the ontology, c) missing subconcepts which are siblings of existing subconcepts; if *left margin* and *right margin* are represented as concepts in the ontology, then we add also concepts *top margin* and *bottom margin* and d) the annotation of concepts in the learning objects; if a concept is represented in the text of a learning object and is relevant for the search within the learning material, we add the concept to the ontology.

After having applied these steps we finalised the working version of the domain ontology. It comprises of nearly 1000 domain concepts, and, additionally, about 50 concepts from DOLCE and about 250 intermediate concepts from OntoWordNet.

As we want to connect the concepts, and later on also the relations between these concepts, with their occurrences in the text of the LOs, we need a) a lexicon for each language which is aligned to the ontology b) a mechanism for recognition of the lexical items in the texts and c) a mechanism for selection of the concept which fits best for lexical units which are ambiguous.

III. Ontology-Based Lexicon Model

In this section we describe the lexicon model and outline the creation of the lexicons for each language on the basis of the ontology. In the context of semantic search, the lexicons serve as the main interface between the user's query and the ontological search engine. The annotation of the learning object is facilitated by an additional linguistic tool, i.e. annotation grammars for concepts. In general, there exist various approaches to the mapping of lexical entries with concepts of the ontology, e.g. WordNet [7], EuroWordNet [8] and SIMPLE [9]. They all start from lexicon compilation for different languages, and then try to establish a links to a conceptual space. Although we draw on the results of these projects (e.g. by mapping our data to WordNet and to Pustejovsky's ideas in SIMPLE), we suggest an alternative approach to connecting the ontology and the lexicons. Our model is very close to that of LingInfo (cf. [11]) with regard to the mapping of the lexical items to concepts as well as to the use of other language processing tools, in particular the concept annotation grammars and disambiguation tools. The terminological lexicons were constructed on the basis of the formal definitions of the concepts in the ontology. By using this approach to constructing the terminological lexicon we evaded the hard task of mapping different lexicons in several languages which has been done by the EuroWordNet Project [8]. The main problems with our approach are that a) for some concepts there is no lexicalised term in a given language, and b) some important terms in a given language have no appropriate concept in the ontology which represents the meaning of it.

To solve the first problem, we allow the lexicons to contain also non-lexicalised phrases which express the meaning of the concepts without being proper lexical units. We explicitly advised the lexicon compilers to add multiple terms and phrases for a given concept in order to represent as many ways of expressing the concept as possible. These lexical units and phrases are used as a basis for construction of the regular grammar rules for annotation of the concepts in the text. If a high degree of lexical variance for a given concept is captured in the lexicon of a language, we are able to capture the different wordings of the same meaning in our learning objects.

In order to solve the second problem, we simply add new concepts to the ontology when needed. The detailed handling of

mmeybodi@aut.ac.ir

a lexical term with no matching concept in the ontology is the following: we insert a more detailed class into the ontology wherever this is possible; for example, the concept *shortcut*, as it was initially defined, was the most general one, but the lexical items used in English to some extent depend on the operating system, because each operating system (MS Windows, Linux, etc) introduces its own terminology. When the notion is transferred into other languages, the equivalents in these languages might denote a different level of granularity – therefore, we introduce more specific concepts in the ontology in order to enable a correct mapping between languages.

In summary, the ontology and the lexicons are connected in the following ways: the ontology represents the semantic knowledge in form of concepts and relations with appropriate axioms; the lexicons represent the ways in which these concepts can be lexicalised or phrased in the corresponding languages. Of course, the ways in which a concept could be represented in the text are potentially infinite in number, thus, we could achieve the lexical representation of only the most frequent and important terms and phrases depicting a particular concept.

In the following, we present an example entry from the Dutch lexicon:

```
<entry id="id60">
  <owl:Class rdf:about="lt4el:BarWithButtons">
    <rdfs:subClassOf>
      <owl:Class rdf:about="lt4el:Window"/>
    </rdfs:subClassOf>
  </owl:Class>
  <def>A horizontal or vertical bar as a part of a
window, that contains buttons, icons.
  </def>
  <termg lang="nl">
    <term shead="1">werkbalk</term>
    <term>balk</term>
    <term type="nonlex">balk met knoppen</term>
    <term>menubalk</term>
  </termg>
</entry>
```

Each lexical entry contains three types of information: (a) information about the concept from the ontology which represents the meaning for the terms in the entry (*owlClass* element); (b) explanation of the concept meaning in English (*def* element); and (c) a set of terms in a given language that have the meaning expressed by the concept (*termg* element). The concept part of the entry provides minimum information for a formal definition of the concept. The English definition of the term facilitates human understanding of the underlying concept. The set of terms represent the different wordings of the concept in the corresponding language. One of the terms represents the term set. Note that this is a somewhat arbitrary decision, which might depend on frequency of term usage or the intuition of an expert. This representative term will be used where just one of the terms from the set is needed, for example as the name of a menu item. In the example above we present the set of Dutch terms for the concept *lt4el:BarWithButtons*. One of the given terms is a phrase; therefore the element has been assigned an attribute "type" with value *nonlex*. The first term is representative for the term set and is therefore assigned the attribute "shead" with value

In the following section we present the process of annotation of documents using annotation grammars Because we still lack proper disambiguation rules at this stage, we performed the disambiguation manually.

IV Semantic Annotation of Learning Objects

Within the project we performed both types of concept annotation, *inline* and *through metadata*.

In the metadata, according the Learning Object Metadata standard (LOM. cf. [12]), some ontological information can be stored for later use in indexing the learning objects. The annotation doesn't need to be anchored to the content of the learning object. The annotator of the learning object can include in the annotation all concepts and relations he/she considers to be important for the classification of this learning object. The metadata annotation is used for the retrieval of learning objects from the repository.

The *inline annotation* will be used in the following ways: a) as a step to metadata annotation of the learning objects; b) as a mechanism to validate the coverage of the ontology; and c) as an extension of the retrieval of learning objects where, except for the metadata, we use occurrences of concepts within the whole documents or its parts (paragraphs / sentences).

We are using concept annotation grammars and (sense) disambiguation rules for the inline annotation. The first kind of information could be seen as an instance of partial parsing tool which for each term in the lexicon provides at least one grammar rule for the recognition of the term in a text. The disambiguation rules are still in a very preliminary state of development and are not discussed further. For the implementation of the annotation grammar we draw on the grammar facilities of the CLaRK System[2].

The inline annotation is performed using regular grammar rules which are attached to each concept in the ontology and reflect the realizations of the concept in texts of the corresponding languages, rules for disambiguation between several concepts are applied when a text realization is ambiguous between several concepts. At the current stage of the project, however, disambiguation has been done manually.

In the following, we will explain in more detail the strategy which guided the semantic annotation. The process comprised the two phases: preparation for the semantic annotation and annotation proper. The former step included the compilation of appropriate regular grammars that explicate the connection between the domain terms in some natural language and the ontological concepts. It involved the construction of a DTD, and of semi-automatic tools for assigning and disambiguating concepts. During the annotation phase the above-mentioned tools were run on the documents. The regular grammar located the occurrences of terms in the text and assigned the potential concepts to each matching term. Further constraints aimed at

[2] cf. http://www.bultreebank.org/clark/index.html

mmeybodi@aut.ac.ir

making the annotation process more accurate. The constraints support the manual annotation in three ways: a) if a term is linked to more than one concept via the lexicon, the user is supported in selecting the most appropriate concept; b) if a term is wrongly linked to concept, and this wrong link can only be detected by looking at the context, this link is erased; c) if only a part of a term (e.g. *Internet*) is marked while a larger, multi-word phrase (e.g. *Wireless Internet*) should be marked, the scope of the annotation is extended. The annotation process has several iterations. A first iteration leads to a more precise annotation grammar and to an annotation of the less problematic cases. With a refined annotation grammar, the more problematic cases are tackled in subsequent annotation steps.

We have annotated all the learning objects for all languages of the project. A reasonable part (at least one third) of all learning objects was annotated in a first cycle which helped improving the annotation grammars for some pilot languages (i.e. Bulgarian, Dutch, English and Portuguese).

In the following, we will describe the use of the ontology, the lexicons, and the annotated learning objects for semantic search.

V. Semantic Search

One of the goals of the project is to develop a search functionality which a) improves the accessibility to documents in a learning management system by exploiting semantic characteristics of search queries and documents; b) works for several languages and c) enables users to find documents in several languages for a search term which is specified in the user's language.

The search engine which we have developed builds on the data which have described in the previous sections, namely a) a collection of documents in several languages, covering one common domain or subject; b) an ontology for this domain; c) lexicons which provide language specific terms for the domain concepts and d) semantic annotation of the documents. Another presupposition is that the user's native language is covered by a lexicon and that there are documents in those languages which the user specifies as his second, third etc. language.

The basic idea of the ontology-based search (or *semantic search*) is that concepts from the ontology lead the user to those documents which are appropriate for his query. The search will probably work best when the user selects concept(s) from the ontology. However, we want users to start with a free-text query for two reasons.

First, the results of the semantic search will be compared to other search strategies such as *full-text search* (all words from the text are considered when looking for a match for the query) and *keyword search* (matching with words that are assigned as keywords to the documents – to avoid confusion, the words the user types in are called *search words* and not keywords). The typical user, who is most probably familiar with the Google search engine, assumingly wants to get the search results fast, with not too many intermediate steps. Therefore, we would like to invoke semantic search as soon as the user has entered his search words, and give first results together with the results of the other search methods. Second, we consider it useful to provide the user a starting point for finding the proper place in the ontology. The search words are used to find this place in the ontology. In a second step, the search can be refined by selecting concepts from the ontology which are close to the search term.

Each concept that is related to the search query is presented to the user together with its neighbourhood from the ontology, i.e. related concepts and relations between the concepts. We will use the term "browsing unit" for the part of the ontology which is presented to the user (see fig. 1 below). If no concept related to the search query is found, the root of the ontology is chosen as the browsing unit. The user can browse the ontology by clicking on a concept. Additionally, the type of relation between the source concept and the neighbouring concept can be chosen in order to narrow down the search space.

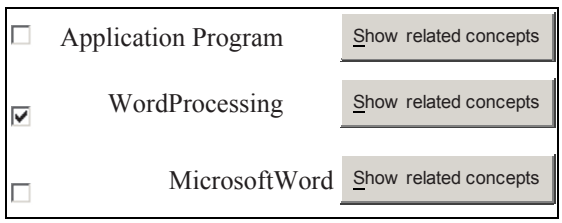


Figure 1 – Example of a possible representation of a browsing unit, where only taxonomical relations are present.

The search engine takes as input parameters: a) the language(s) from which user wants to take search words (determines which lexicons to use for lookup); language(s) for which user wants to see available documents; c) search terms given by user; d) concepts selected by user; e) a method for combining the concepts (either conjunctive or disjunctive); f) two options indicating whether documents should be retrieved which do not contain the desired concept but, for the two options, respectively, a superconcept or a subconcept of it.

The search engine returns a ranked list of documents which semantically match the search word(s), identified by their titles.

The data flow from the user query to the retrieved documents is as follows: a) the search word(s) are looked up in the lexicon(s) of the chosen language(s). Search words are normalised orthographically before lookup; b) if lexical entries are found in the lexicon, they are matched to concepts in the ontology. The respective ontology fragments are presented to the user for further refinement of the query; c) once a set of concepts from the ontology is chosen, those documents which contain the concept(s), either in the metadata or inline, are presented to the user

Several criteria, both the frequency and the position(s) of the search term in the retrieved documents are used to rank the retrieved documents. The documents are shown in the order given by this relevance ranking.

If none of the search words matches a lexical entry or concept, the keywords search and the full-text search are used to retrieve documents. These kinds of searches are part of a fallback

mmeybodi@aut.ac.ir

strategy which guarantees that the user gets a result except in the case that the search word has nothing in common with the document base.

Fig. 2 shows the user interface of the search engine as it is implemented in a prototype of the ILIAS Learning Management System[3].

VI. Evaluation

In a small experiment, which is part of the evaluation of the search function, simple text search and semantic search have been compared. The task which was the basis of this evaluation was as follows: two terms which were also lexical entries in the lexicon of the language under investigation have been chosen as parts of a query (the equivalents of the terms *program* and *slides* in each of the languages). The query has been run on the document set with and without the ontology. This resulted in two sets of paragraphs as the resp. retrieval results. The conceptual annotation has been used to identify the paragraphs in these documents. The conjunction of these two result sets has been investigated by a researcher and each

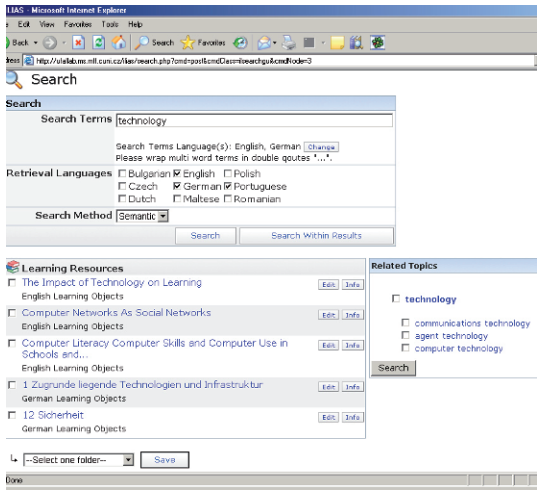


Figure 2 – User interface for search in ILIAS. In the upper part, search words can be entered and languages can be selected. In the lower left part, the resulting documents are listed. In the right part, concepts can be selected.

paragraph rated as either relevant or irrelevant to the search. The retrieval results of both methods (in the following: *text search* and *semantic search*) have been weighted against the set of relevant paragraphs with the well-know measures of recall and precision. Both values have been combined in an F-measure. The F-measure is used to compare the results.

The experiment has been run for six languages: Bulgarian, Dutch, English, German, Polish and Portuguese[4]. The F-measures for both text search and semantic search are presented in table 1. The gain is due to improvements in both recall and precision. It is significant for all languages. The gain is smallest for Portuguese, because there were only a small number of returned documents, and there is visible variation between the languages.

Language	Text Search	Semantic search
Bulgarian	56,25	91,30
Dutch	47,50	94,12
English	27,96	79,42
German	36,00	59.26
Polish	12,50	50,00
Portuguese	28,67	33,33

Table 1: F-measures for full text search and semantic search in six languages.

Another factor that played a role in the results was the context: the narrower the context (e.g. sentences), the better the results, and vice versa.

As has been said before, the conceptual search produces results only in those cases where the search words are in the lexicon and thus matched to concepts in the ontology. This has been the case in the evaluation example. In the case where the search word does not match a lexical item, the text search as well as the keyword-based search is used as a fallback strategy.

It is subject to further user-centred evaluations to reveal how well received the semantic search is in the context of the learning management systems where it is used to solve real tasks. This part of the evaluation is on-going.

VII. Conclusion

In this paper we have presented the current state of the resources and tools for semantic search within the LT4eL project. We have built a lexicon model which relates ontology concepts, relations and instances to lexical items and their occurrences in texts.. The semantic search facility which has been implemented in the context of the project and which is now used by the ILIAS learning management system shows the potential of ontologies in the application domain of information retrieval. An evaluation experiment proved the superiority of semantic search over simple text search in our application domain.

In this model the central role is assumed by the ontology which determines the content of the other components of the model. Another advantage of our model is that it supports the work in a multilingual environment. The mappings between lexicons and ontology are performed with the aim that each term in each language is linked to a corresponding concept, and vice versa – each concept in the ontology is exemplified by at least one expression (be it lexicalized or a free phrase). Thus, the ontology

[3] cf. http://www.ilias.de

[4] For two of the project languages, Czech and Romanian, there were no documents on that specific topic. Neither of the searches yielded therefore any results.

mmeybodi@aut.ac.ir

itself as well as specific language lexicons are verified in a cross-lingual context. We have created lexicons and annotation grammars for all the languages in the project. The mapping between the language specific lexicons was facilitated by the ontology.

Our model shares common features with other lexicon models: with WordNet-like ([7], [8]) lexicons we share the idea of grouping lexical items around a common meaning and in this respect the term groups in our model correspond to synsets of the WordNet model. The major difference is that the meaning is defined independently in the ontology. With the SIMPLE model ([9]) we share the idea to define the meaning of lexical items by means of the ontology, but we differ in the selection of the ontology which in our case represents the domain of interest, and in the case of SIMPLE reflects the lexicon model. With the LingInfo model ([11]) we share the idea that grammatical and context information also needs to be presented in connection to the ontology, but we differ in the implementation of the model and the degree of realization of the concrete language resources and tools.

In future, more work has to be done on the extension of the ontology and on fine-tuning the annotation grammars. In particular, reliable disambiguation rules have to be drafted and tested in order to by-pass manual disambiguation. The connection between the lexicon and the grammars for non-domain dependent concepts has to be investigated further. Last, and by no means least, the impact of the semantic search to typical learning tasks has to be assessed carefully.

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mmeybodi@aut.ac.ir

Workshop in Instrumentation, Sensors, and Engineering (Wise) for Teachers

Magued Iskander, PhD, PE, Vikram Kapila, Ph.D., and Noel Kriftcher, Ed.D.
Polytechnic University, Six Metrotech Center, Brooklyn, NY 11201

Abstract – WISE introduced 20 middle and high school teachers to hands-on engineering design in an intensive two-week residential workshop at Polytechnic University. Teachers were introduced to sensors instrumentation, and engineering in a structured and integrated learning environment. Guided training consisting of lectures, tutorials, structured engineering workshops, and discussions exposed the teachers to foundational elements of engineering through the use of sensors and computerized data acquisition. The program made extensive use of team-based, real-world, engineering design projects based on the components of Project RAISE (Revitalizing Achievement using Instrumentation in Science Education) which has been funded by the National Science Foundation (NSF).

By the end of the project, participants completed 70 hours of in class professional development. In addition, in the evenings and weekend participants took part in planned activities that exposed them to contemporary engineering concerns and projects. These supplemental activities provided an additional 15 hours of professional development.

The project received an overall score of 8.8 out of 10 from participating teachers.

I. INTRODUCTION

American universities must recruit, train and graduate large numbers of scientists and engineers in order for the United States to sustain its "innovation economy" [1–3]. Education in engineering and technology has always been considered more rigorous than education for most other careers. Over the previous 50 years, interest in STEM careers was propelled by the Cold War. However, with the end of the Cold War interest in STEM careers waned. As a result, American engineering colleges face stiff competition from colleges offering competing disciplines. This problem is further exacerbated by several unique negative stereotypes of engineering held by American teenagers. First, engineering is held in lower esteem than other professions, such as medicine, law, and accounting. Second, society tacitly discourages female students from becoming engineers or scientists. Finally, math and science studies are not perceived to be "fun" by high school students.

Today's students are attracted to new gadgets, such as iPods, video games, robots, and cell phones. To them, such "electronic toys" are "hip." We can leverage this as a way to interest students in technology and to motivate them to excel in STEM disciplines [4]. Unfortunately, due to limited resources and shortage of adequately trained high school science teachers, schools often present required science courses in an unimaginative manner. They introduce basic scientific concepts in the abstract, and fail to relate these concepts to science, as encountered by students in their daily lives [5]. This is a major reason for students' losing interest in their science studies. Additionally, uninspiring laboratory experiments contribute to a general lack of interest in studying STEM disciplines, leading to poor achievement on standardized science exams and apathy about pursuing careers in engineering and technology.

A secondary factor resulting in relatively few students studying science and mathematics in college, and an even smaller number studying engineering, is a lack of knowledge regarding career options in science and engineering, or even an awareness of what an engineer does. Exposing teachers to what engineers do is therefore a vital intervention strategy to end this cycle.

Integrating modern sensing technology into science labs makes labs more appealing to students by having them use exciting tools and by allowing students to visualize results graphically and in real time. This is beneficial for learners who rely on visualization. Modern sensors allow inductive and reflective learners to develop inquiry-based learning skills, by developing measurable recorded data. These skills are essential in an increasingly technological society. In addition, those students who are most proficient in science and math will be introduced to contemporary innovations which will make them more likely to be drawn to career paths that are related to science and engineering.

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II. NEEDS ASSESSMENT

High school science and math courses are increasingly viewed as "gatekeeper courses", i.e., students who excel in these subjects succeed in high school and continue their education at college. However, the inherent rigor of science and math, the quality that helps impart this gatekeeper function, also presents great challenges for educational systems. There is a lack of fully-prepared, effective teachers, which limits the achievement of students in Science Technology and Math (STEM) disciplines in K-12 schools [6, 7]. In addition, this chronic problem is currently exacerbated by a general teacher shortage. The result is an urgent demand for continuing professional development of in-service teachers in the STEM areas and for an increased number of adequately trained STEM teachers. To address this need, we designed Project WISE to expose teachers to modern sensing technologies via lectures, tutorials, laboratory activities, discussion, and hands on projects.

The general theme (instrumentation, monitoring, and control) was selected for several reasons: (1) data acquisition is an exciting application that can be understood by pre-college students; (2) data reduction presents an ideal medium to reinforce existing math skills of students and to introduce new skills such as spreadsheets; (3) data analysis provides an opportunity for applying existing science and math skills of students; (4) data visualization affords an opportunity to develop students' cognitive skills and the excitement of self-discovery; (5) through laboratory activities involving modern sensors, students develop inquiry-based learning skills; (6) data acquisition and reduction allows teachers to monitor students' learning and identify areas of weakness; (7) since manual collection and recording of data is not the principal focus of the lab, students will be able to focus on learning the underlying concepts of the lab and formulating and testing new hypotheses; (8) finally, the whole exercise gives students an opportunity to learn and apply state-of-the-art computerized delivery tools such as presentation graphics, document preparation, and spreadsheets. Our approach is in keeping with the time in that students use state-of-the-art equipment similar to equipment used by engineers. Moreover the project directors have extensive experience in sensor, instrumentation, and monitoring technologies through their on-going academic, professional and research activities.

III. BASIS OF CURRICULUM DEVELOPMENT

Funded under a GK-12 Fellows grant by the National Science Foundation, a project known as Revitalizing Achievement using Instrumentation in Science Education (RAISE) placed a dozen Polytechnic students in five selected high schools where they devoted a minimum of ten hours each week to laboratory instruction, in addition to five hours per week of preparation time in which they devise collaborative experiments, pursue research, and utilize planning time [9-12]. Known as RAISE Fellows, these undergraduate and graduate students served as partners with sixteen teachers to integrate modern sensing, instrumentation, and monitoring technologies into two required science courses (i.e., Living Environment and Active Physics) and two electives (i.e., Physics and Marine Science). Indirectly, a basic mathematics course is impacted since the use of instrumentation requires a solid foundation in mathematics. A learning community has been created, including fellows, teachers, high school students, and the project directors of this proposal. Over twenty sensor based lab activities resulted from the judicious integration of sensing technology within the curriculum. Funding for RAISE is concluding, although the five schools which were involved have plans for continued use of the developed material, without the assistance of the fellows.

Our on-going educational outreach activities have led to interactions with hundreds of middle and high school teachers. Thus, we understand local teachers' strengths in STEM disciplines, curriculum and training needs, and level of preparedness in delivering state-of-the-art treatment of STEM disciplines.

IV. RECRUITMENT & TEACHER SELECTION

The David Packard Center for Technology and Educational Alliances (*Packard Center*) is Polytechnic's main instrument for outreach to the K-12 community. Through contracts with NY State and City Departments of Education, the Packard Center provides learning opportunities in science, math, technology, and engineering to pre-college students, teachers, and school leaders. At the proposal stage, the Packard Center obtained tentative commitments from the Superintendents of five school districts in New York State. The superintendents for these districts pledged to help recruit teachers from their districts to participate in this program and to support the curriculum development efforts which ensue.

A brochure describing the WISE program was prepared and disseminated to middle and high school science and math teachers and principals in the participating districts. An information session and open house were also conducted. The value of skills gained through WISE for teachers' future academic and professional growth were emphasized.

WISE was designed for middle and high school teachers with teaching duties primarily in STEM disciplines. In-service teachers with regular appointment in the participating districts provided the pool of participants. Selection was based upon the evaluation of application material submitted by the candidates, which consisted of:

- Cover letter and resume.
- Formal application, containing teacher education, experience, and courses taught.
- Recommendation of school principal and/or science chairperson.

mmeybodi@aut.ac.ir

- A brief essay explaining how WISE-type activities will be integrated into the curriculum.

The selected teachers were a diverse group representative of New York State teachers. Thirteen were men; seven were women. The teachers came primarily from three school districts in Long Island, Westchester and New York City. Thee were 5 physics, 2 biology, 1 chemistry, 5 Math, 2 earth science, and 5 technology teachers. They ranged in age from 25 to 57 years, and in teaching experience from 0 to 32 years. There was also a wide range of familiarity with sensors. We made a conscious decision of including two teachers who were experts in the use of sensors in class room through participation in RAISE to serve as master teachers.

V. THE WISE SUMMER TRAINING WORKSHOP

WISE introduced participants to hands-on engineering design in an intensive two-week (August 13–24, 2007) residential workshop at Polytechnic University. In class activities consisted of lectures and real world engineering projects focused around the grade 7-12 curriculum. By the end of the project participants completed 70 hours of in class professional development. In addition, in the evenings and weekend, participants took part in planned activities, which exposed them to current engineering issues and achievements. These supplemental activities provided an additional 15 hours of professional development. The typical daily activities consisted:

8 – 9 AM	Breakfast & Informal Discussion
9 – 10:30 AM	Intro. to Engineering
10:45 – 12:45 PM	In Class Projects
12:45 – 1:30 PM	Lunch
1:30 – 3:30 PM	In Class Projects
3:45 – 5:15	Pedagogical Discussions
5:15 – 7:30	Dinner
7:30-9:00	Presentations on Current Engineering Issues

Teachers resided on campus for the duration of the project in order that they may pursue their studies with a minimum of distractions, and in order to facilitate the development of a supportive network of teachers dedicated to their students' pre-engineering studies. Moreover, professional and social meetings were held at night to enable participating teachers to network with practicing engineers from the local engineering community.

The project's benefits to participating teachers included: (1) reinforcing their subject matter knowledge in science and math; (2) enriching their experience and technological literacy through exposure to real-world, hands-on, multi-disciplinary engineering design; (3) developing and honing their research, communication, and presentation skills; and (4) offering opportunities to network with scientists, engineers, and other local area educators.

Teachers' schools also benefited since the project attendees were imparted the ability to: (1) provide their students with a solid foundation for advanced study and careers in engineering/technology; (2) develop new courses to integrate hands-on activities with content and performance standards to meet Standard 5 – *Technology of the New York State Learning Standards in Mathematics, Science, and Technology* and the goals of *NYS Technology Education Framework Initiative* [8]; (3) assist students to perform research and participate in science and engineering competitions; and (4) become science and technology ambassadors in their schools.

Project Objectives

The project objectives address several common areas of need, as follows:

- Introduce teachers to instrumentation and monitoring in a structured learning environment and in the process reinforce their math, science, and pre-engineering knowledge and skills.
- Provide teachers with skills, and resources necessary to deploy sensor based labs in their high schools, thus enabling them to:
  - integrate project-based learning and active learning in the science and math curriculum;
  - enhance science labs by (1) bringing real-world experience to labs, (2) infusing cutting-edge technology, and (3) acting as a resource for colleagues engaged in lab development efforts;
  - foster in their students the development of technological literacy and skills
  - improve their research, communication, and presentation skills;
  - encourage their students to participate in and scientific competitions; and
  - inspire their students to pursue careers in science and engineering.

Overview of Curriculum Development

Participant's applications were used to reveal salient teacher characteristics, e.g., educational background, teaching experience, attitudes/beliefs about teaching, technical skills, and self-perception. Next, at the beginning of the program, a questionnaire was administered to the selected teachers to gauge their existing basic knowledge of the following topics: (1) mechanics, (2) circuits, (3) sensors, and (4) computer technology. The authors and their research assistants analyzed the information for instructional design.

Sensor-based laboratory projects relevant to grades 7–12 have been developed as part of our RAISE program. We

mmeybodi@aut.ac.ir

selected from those experiments, based on the background of the participating teachers, to design a program tailored to the needs of the participants. These experiments have been developed through extensive interactions with pre-college teachers, and tested in five NYC high schools.

Overview of Introduction to Engineering Tutorials

Participants received 15 hours in tutorials that introduced them to various engineering disciplines and principles and tools of engineering design. These tutorials covered the following topics:

- Introduction to civil, mechanical, and electrical engineering
- Basics of engineering design including elementary mechanics and stress analysis.
- Measurement fundamentals including electronic measurement of strain, force, pressure, deformation, and tilt.
- Introduction to mechatronics

The presented material was specially developed for the participating teachers with an understanding of their educational backgrounds. We made extensive use of multi media in these lectures in order to present the basics of engineering to an audience of non-engineers in an entreating and attractive fashion without watering down the content. Participants also enjoyed visiting the various engineering labs at the civil and mechanical engineering departments and watching demonstrations of numerous experiments.

As part of the introduction to engineering sessions, Participants were engaged in identifying examples of sensing in society, from their routine interaction with home appliances (e.g., climate control units, dish/laundry washers and dryers, refrigerators, etc.), automobiles (e.g., odometers, dashboard indicators, cruise control, active suspension, electronic ignition and fuel injection, and air bags), and public facilities (e.g., New York City subway, elevators, traffic signaling units, and airports). Participants recognized the widespread use of modern sensors in their own communities.

Overview of In-class Projects

In-class projects were designed to expose teachers to modern sensing technologies via laboratory activities and hands on projects. An important feature of the workshop is that each teacher received a measurement kit valued at $1700, to use during the program and to take back with them to their school. Teachers gained expertise in the use these kits through 40 hours of in-class projects. In the first week, each session consisted of a half-hour discussion of a typical engineering problem that can be simplified and simulated in a school science lab. Next, teachers in groups of three or four spent approximately one hour performing the sensor based experiment. Finally, the group devoted half-hour to discussing the results and how they can be implemented in their own classrooms.

All labs utilize low-cost modern data acquisition tools in a high-level graphical user interface environment which was used by participants to monitor and plot sensor data. These tools also allow spreadsheet support for advance data analysis. Hands-on activities illustrate some of the real-world applications of material covered in the engineering tutorials, thus reinforcing and imparting a deepened understanding. The discussion time for each session provided participants with an opportunity to reflect on, and further explore, ways to integrate these activities in their classrooms.

The in class project activities addressed Standard 5 in the *New York State Learning Standards in Mathematics, Science, and Technology* [8]. Specifically, Standard 5 fosters technological literacy by requiring students "to apply technical knowledge and skills to design, construct, use, and evaluate products and systems." In-class projects targeted the following skills outlined in Standard 5: (1) modeling and optimization for engineering design; (2) facility with selection and use of technological tools, materials, and processes; (3) ability to use the computer as an engineering design and information processing tool; (4) understanding of systems engineering principles; and (5) management of technology to develop efficient and effective products and processes.

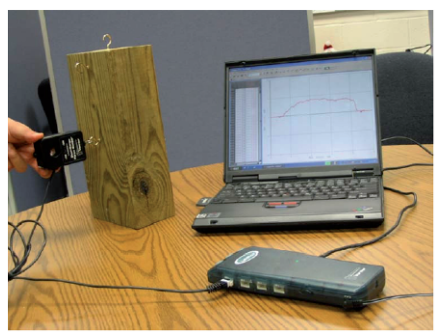


Fig. 1 Stability Experiment

Typical In Class Project: In the stability experiment, teachers were first familiarized with the notion of instability in civil engineering structures, in the form of sliding and overturning. Examples of landslides, retaining wall failures, and toppling of cranes and excavators were presented. Next, participants performed an experiment using a force sensor by pulling on a wooden block until the block tips or slides. Use of real-time data acquisition allows participants to visualize the instance when the applied force exceeds the resisting force, thus initiating sliding or overturning.

Participants were then assigned to compute critical forces and compare them with sensor measurements to validate Newton's laws of motion and friction effects. This activity

mmeybodi@aut.ac.ir

was followed by thought-provoking questions such as, "Which face of the block will require the least amount of force to be overturned?" Participants were able to formulate and investigate their hypothesis by conducting the experiment again by changing the position of the hooks and by applying the force on each face of the block with the force sensor. Such an experiment allows them to discover on their own that the shorter the resisting lever arm from the point of rotation, the lesser the force required to overturn it.

Overview of Teacher Designed Lab Experiments

During the second week, half of the lab sessions were dedicated to developing prototype sensor based experiments. To ensure that the teachers remain engaged, excited, and motivated to excel in the project activity, they were tasked to carefully select projects that illustrate grades 7–12 level STEM concepts. Teams of 3-4 teachers, grouped by subject taught, worked together to construct sensor-based experiment from their own curriculum, such as:

- speed of magnetically levitated train and the its force of impact
- acceleration in an elevator on its ascent and descent
- drop in temperature due to the addition of salt to water
- vital capacity of the lung

We believe these hands-on projects helped introduce teachers to engineering design. Perhaps more important is that they provided each teacher with one or more sensor based project that they personally developed and thus are more likely to use in class.

Overview of Pedagogical Discussions

Participants spent 15 hours in instructor led discussions. The discussions revolved around pedagogy and technology. Case histories of active learning with sensors were used to discuss the role of technology in education. These discussions focused on contemporary technology-related pedagogical issues such as the role of e-learning in K-12 education; influence of culture and gender preferences on technical education; role of visual modeling in engineering education; relationship between pedagogy, ethics, and technology; student attitudes towards technology and privacy; student assessment using automated technology; balancing security with privacy issues; and role of games models, and multimedia in the classroom.

Overview of Presentations on Current Engineering Issues

Participants spent 20 hours in out of class planned activities, which exposed them to contemporary engineering issues. The evenings guest speakers from the local engineering community were invited to speak about current engineering concerns, such (1) reconstruction of the world trade center, (2) supply chain management for a global manufacturing concern; (3) women in engineering, (4) the process of technological innovation, (5) rail car diagnostics, (6) 4D modeling in construction, (7) effect of environmental values on decision making (NEPA), (8) real-time monitoring of excavation near an operational subway line, and (9) use of recycled plastics in construction. These talks and discussions lasted for approximately 90 minutes each. On Saturday we arranged guided trips to The Skyscraper Museum, and The Transit Museum. An important benefit of these night and weekend activities was that participants developed an appreciation for the relevance of science and math skills to solve real-world technological problems.

Overview of Organizational Structure

WISE was supervised by two engineering faculty, and one liberal arts faculty. The three project directors are also the principals of the RAISE project. The directors were assisted by several graduate and undergraduate research assistants, who served as lab assistants and helped the directors in the development of instructional material.



Fig. 2 — Evaluation Results for WISE Components

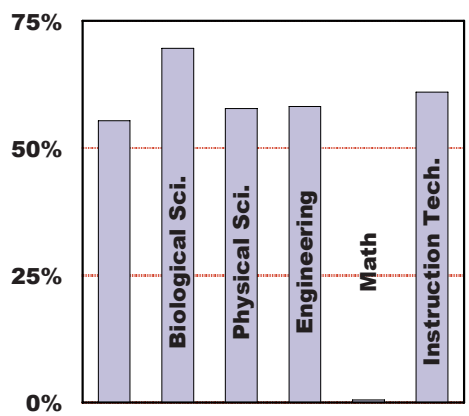


Fig. 3 — Improvement due to Participation in WISE

mmeybodi@aut.ac.ir

VI. PROJECT ASSESSMENT

Comprehensive beginning and end of program surveys were compared in order to verify whether (1) the team developed and delivered an engaging and educational "engineers of the future" program, and (2) to what extent teachers reinforced their STEM skills and learned fundamental elements of sensing and engineering.

Teachers rated all areas of the program Very Good to Excellent (Fig. 2). The teachers also gave WISE an overall grade of 8.8. The main area of complaint was the length of the day, with many suggesting that the dinner break be shortened and the day end earlier. Statistical analysis of pre- and post-project surveys indicate that teachers reported an average improvement of 55% when comparing their self evaluation before and after attending WISE (Fig. 3). All areas showed improvements except math skills. The reported improvement in all areas other than math ranged between 58% to 70 %. Math skills were not specifically targeted, and it appears that participants did not believe that their math skills improved over the two-week project duration.

At the end of the project, participants were required to present to the group the sensor-based experiments that were developed for their classes. These experiments clearly demonstrate that participants are able to integrate newly acquired skills to develop lesson plans for use in their classrooms.

Finally, each teacher was asked to maintain a project portfolio, including a description of how their experience will be integrated in classrooms. Participants were invited back to Polytechnic in Fall 2007 to report to the group on how they integrated the project activities in their schools.

VII. SUSTAINABILITY

The Packard Center will provide leadership for project sustainability by ensuring that teachers and university-based professionals continue to collaborate beyond the summer workshop. Strategies for sustainability include developing mentoring relationships with university and industry professionals (e.g., through participation in engineering design competitions), scheduling tours of labs and industry facilities, offering science experiments on loan to schools, and supporting efforts of superintendents and principals to integrate project activities in their schools. A key component for sustainability is that teachers will take back the instrumentation kits to their schools, thus allowing them to implement what they learned in their own classrooms.

VIII. CONCLUSIONS

All available evidence indicates that participation in WISE resulted in a measurable increase in teachers' knowledge in physical and biological sciences, engineering, and pedagogy. Teachers also demonstrated their ability to integrate the newly acquired knowledge about sensors and engineering within the Grade 7-12 curriculum. It is therefore anticipated that participating tachers will become science and technology leaders in their schools by undertaking curriculum reform, lab development, and student mentoring.

IX. ACKNOWLEDGEMENTS

WISE was funded by NY State Education Department Engineers of the Future Program Grant No: C400687. The authors thank Richard Organisciak, Superintendent of New Rochelle SD and Arnold Goldstein, Assistant Superintendent of Bellmore Merrick SD for their support. Most lab exercises were developed under NSF grant DGE-0337668: GK12 Revitalizing Achievement by using Instrumentation in Science Education (RAISE). The authors thank the following Polytechnic research assistants who's participation in WISE made it a success: Brandi Barra, Amir Bozerg-Haddad, Harish Chandra, Alp Gokce, Mahmoud Mahmoud, and Ilya Zarankin. Finally, the authors wish to thank the participating teachers for attending the WISE project.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

A Course in Instrumentation & Monitoring of Civil Infrastructure

Magued Iskander, PhD, PE, Edwin Yu, and Nerik Yakubov
Polytechnic University, Six Metrotech Center, Brooklyn, NY 11201

Abstract— Use of field instrumentation to monitor the on-site behavior of structures is increasingly becoming a part of many construction projects. Nevertheless, few American universities, if any, offer a course on instrumentation as part of their Civil Engineering curriculum. To address this concern, a graduate course titled "Instrumentation, Monitoring and Condition Assessment of Civil Infrastructure" (CE 607) was developed and offered at Polytechnic University for the first time in the spring of 2006. Thirteen modules of the course were developed. The intent of this course is to familiarize graduate students with the principles of instrumentation and monitoring, including planning, sensor selection, data acquisition, information management and error analysis in civil engineering projects. By the end of the course, the engineers are expected to have the ability to develop and conduct an instrumentation program.

I. Introduction

Instrumentation in Civil Engineering projects is widely used to help engineers monitor the behavior of soils and structures due to on-site conditions. In the early twentieth century, instrumentation was primarily used in the laboratory to measure strength parameters of construction materials. In the 1940's Ralph Peck pioneered the use of electronic instrumentation to monitor structural performance of excavation support systems during the construction of the Chicago subway system [1]. Peck initiated the method known today as the *observational method* where instrumentation data is used to validate whether the original design is yielding acceptable performance. Unacceptable performance is typically remedied with timely precautionary changes.

The use of field instrumentation to monitor the on-site behavior of structures is becoming part of many construction projects. Nevertheless, few American universities offer a course on instrumentation as part of their civil engineering curriculum; so many engineers learn instrumentation through the school of hard knocks. A common scenario for civil engineers who first get involved with instrumentation work is to quickly learn about instrumentation on their own, which often results in poor instrument selection and/or wrong monitoring location(s). To bypass their inexperience in instrumentation, engineering firms quite often purchase the most expensive instruments and place them in too many monitoring locations, resulting in unnecessary overhead costs.

Instrumentation courses in Mechanical Engineering departments are sometimes the only option for Civil Engineers to learn about sensing technology. Mechanical engineers typically use sensors that are different from civil engineers.

II. Civil Engineering Education

Civil engineering has been established as an independent field of study for approximately a century. Unfortunately, despite significant changes in civil engineering practice over the last three decades, civil engineering education has remained virtually stagnant throughout this development. There has been increasing recognition of the importance of the surrounding environment on the design and construction of projects of all sizes. Many professional organizations informally transfer this knowledge from senior to junior engineers through the school of "hard knocks." Some universities invite guest lecturers to address these issues in an ad-hock fashion, using field examples and case histories. Therefore, civil engineering is often taught in isolation of the surrounding environment.

Given the complex and inter disciplinary nature of rehabilitation work, students should have much more multi-disciplinary and experiential knowledge about varying fields than what they currently possess, on average. In addition to basic and applied courses in conventional civil engineering topics, students should also be exposed to mechanical and electrical engineering, instrumentation, and material science. Communication, presentation, writing and demonstration skills must be taught and emphasized through the curriculum. A basic understanding of financial processes, law, human resources, management processes, innovation and quality control are needed to equip engineers with the skills needed to advance in their careers.

It has been said that the best way to predict the future is to create it. This course was developed in an effort to change the civil engineering curriculum as it is conventionally offered.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 292–297.
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III. Role of Instrumentation in the 21st Century

The world's population is likely to increase by 25% in the next 50 years. Virtually all of this growth will be in cities in need for major infrastructure renewal. Rehabilitation work is different from conventional construction in a number of ways. First, the work is complex and inter disciplinary in nature. Second, the impact on adjacent buildings and utilities is great. Third, the subsurface site conditions can never be fully predicted in advance. Fourth, soil properties can vary dramatically within one site, and even within the same soil formation, depending on the site history. Fifth, environmental risks on developed land are different and greater than virgin soils. The demands and uncertainties involved in modern infrastructure renewal projects point to the need to use instrumentation on many current projects.

Over the past few decades, architects and engineers have pushed their limits in designing new infrastructure. For the most part, this was possible due to the development of new computer design software, such as finite element analysis. However, as much as computer software aids in the design process in the office, it does very little when it comes to actual construction. An important tool that enabled the advancement of the state of the art in field construction has largely been the use of instrumentation to verify the performance of as built structures. Instrumentation can be used to establish cross-checks on the development of new analytical predictions and computer models to further tighten the gap between theory and reality.

There are several current developments that are advancing the state of practice. One of these developments is the use of wireless sensor networks. The use of wireless sensors has two major advantages. The first is that it saves on cost. The expenses of running wires around a construction site can add up to tens of thousands of dollars and eventually put a project over budget. The second advantage of using wireless is that it avoids the delays that wires can cause by impeding contractors on a construction site. Wireless sensors will most likely cause a significant increase in the use of sensors to monitor construction in the next two decades.

Another developing trend is the use of sensors to monitor the success of new construction methods. Sensors verify whether a new technique successfully achieves the desired criteria before it is adopted as a widely accepted practice. This will add to the important role of instrumentation and its function in the future.

IV. Course Objectives

To address the preceding needs, a course on Instrumentation, Monitoring, and Condition Assessment was developed and offered at Polytechnic University for the first time in spring 2006. To the best of the authors knowledge a similar course does not exist. This course has several objectives, as follows:

- to provide awareness to engineering students of the wide use of instrumentation in civil engineering projects;
- to familiarize students with the design, manufacture, selection, and installation process of both laboratory and field instrumentation;
- to familiarize students with data management and error analysis of the measured data;
- students gain the ability to plan effective instrumentation programs;
- to familiarize students with some business aspects of instrumentation
- to familiarize students with the use of instrumentation for non destructive testing and condition assessment in civil engineering
- to impart an appreciation of the need of a multidisciplinary education because instrumentation skills require basic knowledge of many aspects of engineering, including electronics, mechanics, and fluids.

V. Course Description & Role in Development

The course is organized in 14 2.5-hour modules (Table 1). Each module typically consist of 100-120 power point slides. The first module is an overview of basic engineering concepts and the required instrumentation skills. Topics such as mechanics of materials and common material properties of steel and concrete, as well as fundamentals of electronics and fluids are covered.

The actual instruction on instrumentation and monitoring starts with the second module: Measurement of Strain. The reason that measurement of strain is so important is that most other engineering parameters, such as load, pressure, and deformation, can be derived from strain using Hook's law. This module presents electrical resistance strain gauge and its evolvement from laboratory use to field construction. A more recent and most commonly practiced way of measuring strain is through vibrating wire technology.

The third module builds-on the second. A variety of strain based load cells and pressure cells (fluid and earth) are presented and discussed. Other methods of measuring pressure are also introduced. In chapter 4, an array of deformation gauges, such as LVDT's and crack gauges, and inclination instruments, such as tiltmeters and inclinometers, are discussed. The third and fourth modules typically covered theory, sensor design, field installation, data interpretation, and case histories.

The lecture on Surveying was included because surveying is increasingly becoming a smaller part of conventional civil engineering in American universities. A brief introduction to conventional surveying methods, such as taping, leveling, and traversing, is covered, as well as more advanced methods, such as the use of robotic total stations and automated Theodolite systems.

mmeybodi@aut.ac.ir

The lecture on Data Acquisition and Signal Conditioning was the most challenging module to develop. Aside from the fact that this topic is covered as a complete course at most universities' mechanical or electrical engineering departments, it had to be compacted into one lecture for this course. This lecture includes discussions of signal sampling and aliasing, signal conditioning, and data logging for field services.

Table 1: Course Outline

Lecture #	Lecture Title
1	Material Properties & Instrumentation skills
2	Measurement of Strain
3	CE Sensors for Static Applications 1: Measurement of Load & Pressure
4	CE Sensors for Static Applications 2: Measurement of Deformation & Tilt
5	CE Optical Measurements: Surveying
6	Data Acquisition & Signal Conditioning
7	Error Analysis
8	Planning, Executing & Business Aspects of Instrumentation Programs
9	Introduction to Mechatronics
10	CE Sensors for Dynamic Applications: Monitoring of Vibrations
11	Condition Assessment of Concrete & Masonry Structures
12	Condition Assessment of Steel and Timber Structures
13	CE Sensors for Environmental Condition Assessment: Monitoring Air & Water Quality
14	Presentation of Student Projects

Lecture seven dealt with error or uncertainty in engineering measurements. Two common types of errors, commonly known as systematic and precision, are presented, along with the treatment for each error. In addition, key terms in measurement uncertainty are introduced and defined.

Lecture eight demonstrates a 21-step systematic approach to planning and executing an instrumentation program. This approach was outlined by John Dunnicliff, a well known author and instrumentation consultant [2]. This chapter also offers some case histories as to the actual instrumentation layout for a bridge, a building, a dam, and a tunnel

An introduction to Mechatronics is presented next. Mechatronics is the study of the combination of computers, electronics, and mechanical elements. Mechanical engineering sensors are introduced to explore the possibility for civil engineers to use Mechatronics to monitor the behavior of civil infrastructure.

Lecture ten discusses instrumentation for dynamic measurements such as monitoring effects of wind and earthquakes on structures and the effect of blasting and pile driving on nearby structures. Performance and operating principles of accelerometers and geophones for monitoring vibrations are discussed.

Lecture eleven discusses condition assessment techniques for concrete, and masonry structures. Typical methods and equipment used for evaluating concrete and masonry structures is presented. Additionally, non-destructive procedures of concrete and masonry structures are also introduced.

Lecture twelve discusses the skills necessary to evaluate the physical condition of steel and timber structures. Typical equipment used for evaluation of steel and timber structures is presented. Additionally, non-destructive procedures of both structures are also introduced.

Lecture thirteen on environmental sensors has two objectives. First, to familiarize students with common instruments used in the lab and field for environmental assessment, such as pH and toxic gas sensors. And second, to reemphasize to the students that instrumentation is a multidisciplinary subject and is practiced throughout the Civil Engineering discipline.

In the last session groups of 2-3 students presented projects that they had worked on for the entire semester. The projects represented a third of the grade. The projects dealt with either case histories or performance of sensors not covered in the lectures

VI. Inter Semester Survey

The course development represented a number of challenges that were addressed through a mid semester course evaluation. First, there were no similar courses to model. Second, the course built on multidisciplinary knowledge in electrical and mechanical systems, areas that civil engineering students are typically not well versed in. Third, there was no suitable text book that can be used. An inter-semester survey was conducted with 19 out of 23 registered students taking the class in the spring of 2006. The inter-semester survey includes results for only 10 out of 14 modules of the course.

The first set of assessment questions deals with the level of difficulty of the CE 607 course. The survey begins by recording the average response to the following statements:

- I typically spend 7.9 hours studying for a typical lecture in a Polytechnic class.
- Excluding homework, the time I spend studying for each CE607 lecture is 3.4 hours
- CE 607 homework typically takes me 2.8 hours to complete.
- I expect the CE 607 project to take 16.5 hours (equivalent to 1.2 hours per week)

From these responses, it is deduced that an average student spent approximately 7.4 hours studying for each CE 607 lecture. Accreditation Board for Engineering and Technology

mmeybodi@aut.ac.ir

(ABET) requires the student to study 3 hours for each hour of class, so for a typical class at Polytechnic, which is 2.5 hours per week, this would equate to 7.5 study hours per week. CE 607 carried approximately the same time commitment from the student as required by the ABET standard. In comparison to a typical course at Polytechnic however, the time commitment for CE 607 was slightly lower than reported for other courses. Furthermore, Table 2 illustrates that the majority of the students responded that each lecture was "Just Right" as opposed to being "Easy" or "Difficult." A separate question asked which were the easiest and the most difficult modules. To the question, "What is the easiest module?" 10 students responded 'Introductory Material' and five responded 'Surveying.' To the question, "What is the most difficult module?" six students responded 'Error Analysis,' four said 'Measurement of Strain' and another four said 'Data Acquisition and Signal Conditioning.'

Table 2: Feedback on Level of Difficulty

Lecture	Easy	Just Right	Difficult
Introductory Material	9	10	0
Strain	4	13	2
Load & Pressure	3	15	1
Deformation & Tilt	3	16	0
Surveying	5	13	1
Error Analysis	1	13	4
Environmental Assessment	2	15	2
Planning	3	15	1
Data Acquisition	0	15	4
Mechatronics	1	16	2

Table 3: Feedback on Course Design (1 = Lowest, 10 = Highest)

Lecture	Usefulness	Clarity	Understanding
Introductory Material	8.7	9.4	9.6
Strain	9.3	9.2	8.7
Load & Pressure	9.3	9.0	8.7
Deformation & Tilt	9.1	8.7	8.4
Surveying	7.9	8.9	8.8
Error Analysis	7.9	8.2	8.1
Environmental Assessment	7.7	8.2	7.6
Planning	8.2	8.3	7.9
Data Acquisition	8.2	8.4	7.8
Mechatronics	7.4	8.9	8.3

The second set of assessment questions provides feedback on the course design. Table 3 illustrates an average rating on the usefulness, clarity, and student understanding of each lecture. All modules were rated with a score of 7.4 or higher. Table 4 exhibits the level of educational preparedness that student had for each module. It is evident that knowledge of electronics is about 2 points lower than knowledge of math for almost every lecture. One way to address this difference is to offer a more intensive review of electronics in the introductory module. Nevertheless, no item was given a rating lower than 7.0.

Table 4: Level of Preparedness for Taking this Course

(Scale 1 = Lowest, 10 = Highest)

Lecture	Math	Electronics	Mechanics
Introductory Material	9.7	7.9	8.5
Strain	9.4	7.5	8.2
Load & Pressure	9.5	7.9	8.1
Deformation & Tilt	9.4	7.8	8.1
Surveying	9.2	7.6	7.5
Error Analysis	9.1	7.1	7.0
Environmental Assessment	9.2	7.3	7.5
Planning	9.1	7.1	7.0
Data Acquisition	8.9	7.7	7.5
Mechatronics	9.2	7.5	7.5

An attempt to collect feedback for improving the course is shown in Table 5. This part of the survey was completed by only 17 students. The most requested item was additional worked examples. The majority of responses, however, suggested no changes. The course also compared well with other Polytechnic courses (Table 6). Most, if not all, of the responses are positive. For example, in the first question, only one student replied that the course was not appropriate for his major, while nine said "Maybe" and eight responded "Definitely." In the question "This course made me understand the importance of a multidisciplinary education," an overwhelming majority of the students replied "Definitely."

Table 5: Feedback for Improvement

Lecture	No Changes	Suggested Changes
Introductory Material	16	None
Strain	13	Review Wheatstone Bridge more
Load & Pressure	14	More examples
Deformation & Tilt	14	More examples
Surveying	11	Bring in tools for demonstrations
Error Analysis	12	Spend two lectures or reduce the content
Environmental Assessment	11	Can be made more interesting
Planning	12	More examples on the 21-step procedure
Data Acquisition	14	None
Mechatronics	13	None

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Table 6: Comparison to Other University Courses

	Definitely	Maybe	No
The course is appropriate for my major	8	9	1
The course is appropriate as a core-course	4	14	0
The handouts were sufficient as study material	12	3	2
This course is too easy	0	8	10
This course is too difficult	1	7	9
The homework is appropriate for the lecture material	14	3	0
The course made me explore new ideas	11	6	0
This course made me understand the importance of a multidisciplinary education	16	1	1
The pace of this course is too fast	1	10	7
I found the use of graphics and clip art helpful	15	2	1

VII. Post-Semester Survey

The post-semester survey [3] was taken by 15 out of the 23 registered students. The post semester survey is conducted by the university for all courses, as a measure of quality control. Most of the questions related to the quality of instruction, and the level of preparedness of the instructor. However Selected answers relating to course design are presented in Table 7- 9.

Table 8 illustrates student responses on the comparison of CE 607 to other courses at Polytechnic University. All students replied that the difficulty of the course is "Fair." Furthermore, most students responded that the pace and size of the course is "Fair." The complaint that the class was "Too Big." is valid, since most Polytechnic graduate courses have smaller enrollment. The complaint resulted from the topic being too popular and its offering for the first time.

Table 9 illustrates that the overall rating of the course and lecture instruction are "Great." It seems that most, if not all, of the responses are positive. Nevertheless, no responses were given as less than "Fair."

VIII. Unedited University Survey Student Comments

- The course is very interesting and I learned a lot of new subjects I wasn't familiar with. Professor Iskander was very professional and taught this course in an appropriate manner
- Good Course!
- As it is the first time for CE 607, I can say that it was performed in an excellent manner!

Table 7: University Evaluation

	Very Great Extent	Great Extent	Moderate Extent	Limited Extent	Not at All
This course is appropriate to your major.	9	5	1	0	0
Written & oral communication were important parts of this course.	9	4	2	0	0
The effort required to complete assignments, or reports, is appropriate for the course.	12	3	0	0	0
Assignments are relevant to course material.	13	2	0	0	0
Exams accurately assess the student's performance in the course.	8	6	1	0	0
Instructor presented real-life applications of course material	13	2	0	0	0
A variety of teaching methods was used for instruction.	8	6	1	0	0
Multimedia resources are used in class for instruction.	12	2	1	0	0
The syllabus, assignments, and/or other materials were made available on the Internet.	10	5	0	0	0
Internet resources were suggested to support course materials.	7	4	3	1	0

- Thank you for your great presentation of the course. You are one of the few professors at Poly who spends time on presentations and preparation for the class.
- Please provide more Civil Engineering applications.
- Too much material covered on some presentations.

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- More in class-problems/solutions.
- Materials are too general. The course should concentrate on more Civil Engineering related topics.
- You should write a textbook to go along with the course. I need more example problems other than the homework.
- A book would help as a reference. The course combines various engineering aspects.
- It would be better if there is a textbook.
- Conduct site visits to take photos and observe instrumentation work first hand.
- Provide more practical examples of how instrumentation is used and the results implemented. An ideal way to deal with this would be to consult with instrumentation companies and manufacturers.
- Develop hands-on workshops or laboratory work to go along with the class lectures. Possible experiments can be conducted emphasizing the operating principle technology of the following transducers:
  - Electrical Resistance Strain Gauge
  - Vibrating Wire Strain Gauge
  - Linear Potentiometer
  - Linear Variable Differential Transformer (LVDT's)
- Develop the use of wireless sensor networks and Mechatronics in Civil Engineering
- Conduct research on sensors for homeland security

IX. Conclusion

It is concluded based on the student surveys that (1) the course was well received, (2) the level of difficulty is consistent with ABET, (3) the course design is appropriate for civil engineering students.

The lack of a text book was effectively overcome through the development of an extensive set of slides, consisting of 1570 slides, most containing graphics. Use of graphics and clip art proved helpful to students.

The course helped students developed appreciation for a multidisciplinary education.

Table 8: Compared to Other Courses Taken at Polytechnic

The course is :	Too Hard	Hard	Fair	Easy	Too Easy
	0	0	15	0	0
The pace of the course is:	**Too Fast**	**Fast**	**Fair**	**Slow**	**Too Slow**
	1	3	11	0	0
The size of the class is:	**Too Big**		**Fair**		**Too Small**
	4		11		0

Table 9: Overall Evaluations

	Great	Good	Fair	Poor	Inadequate
Overall rating for this course is:	10	4	1	0	0
Overall rating for the lecture instruction is:	11	3	1	0	0

X. Acknowledgements

This work could not have been completed without the support of the National Science Foundation through Grant DGE-0337668: Revitalizing Achievement by using Instrumentation in Science Education (RAISE). The first author was a Co-PI of the grant, and the second and third authors were RAISE (GK-12) Fellows. Vikram Kapila was PI and Noel Kriftcher was Co-PI. The primary responsibility of the PIs and Fellows was to improve the teaching of science in 4 New York City high schools through the use of sensor-based labs. Nevertheless. funding from NSF allowed the authors to dedicate the massive time necessary to develop this course.

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mmeybodi@aut.ac.ir

Explaining Swarm Design Concepts Using an Interactive, Bottom-up Simulation Tool

Marc Kirshenbaum, Daniel Palmer, Phillip McCullick, and Ravi Vaidyanathan

Abstract—When promoting emergent behavior as a viable problem-solving option to a community unfamiliar with the concept but nevertheless key stakeholders in the effort, swarm researchers can find themselves making rudimentary analogies to social insects that provide some familiarity, but offers nothing in the way of real understanding. Yet, if these stakeholders are to adopt such a seemingly radical approach, they need to be somewhat conversant with the concepts, the obstacles and the process of an emergent system. We have built an Emergent Behavior Simulation Tool (EBST) to make issues of emergent systems and bottom-up design quickly accessible to interested neophytes. The contextual scenarios are built by swarm researchers, but provide an interface accessible to all. The tool provides an environment in which the consequences of agent based actions can be observed at the global level, and then quickly changed based on observations. Yet the scenarios are specific, and goal-oriented, so that the swarm-layperson is not left to fend for themselves in a sea of syntax, and open-ended possibilities. The tool is the centerpiece of an online course being developed for military students at the US Naval Postgraduate School.

Index Terms— *Artificial Intelligence, Computer Integrated Education, E-learning Tools, Emergence, Instructional Design, Multi-Agent Systems, Swarm Modeling*

I. Introduction

When Darley [3] stated "swarm behaviors cannot be predicted, only observed" it begged the obvious question of how does one actually teach the concept as a problem solving tool without a fundamental level of observation/experimentation. This level of experimentation, however, remains a daunting task for any student who does not possess significant background in programming such that they may construct objects in a build/experiment/modify cycle typifying a decentralized architecture. This gap has forced the rigorous construction of decentralized/swarm architectures to remain primarily within the realm of computer science and engineering at this time.

The goal of our work is to enable the broader access to emergent design tools to a wider array of students through the use of an *Emergent Behavior Simulation Tool* (EBST) enabling the architectural construction of swarming strategies for students without a significant learning curve and time investment. The simulation tool is based on case studies for insect and robotic behavior. Targeted audiences at this time include: 1) introductory science students for whom the concept can be introduced prior to subsequent courses in programming, 2) students in business, psychology, social sciences, economics, and military studies for whom the concept of decentralized emergence is vital, yet do not have extensive programming background, and 3) students of all backgrounds studying decentralized or multi-agent systems through e-learning over the internet. In the longer term we also envisage the core of this tool to serve as a research aid to rapidly construct decentralized architectures for distributed control systems for all manner of applications.

Manuscript received October 5, 2007. This work was supported in part by the U.S. Naval Postgraduate School Integrated Distance Learning Foundation under the supervision of Tom Hazzard.

Marc Kirshenbaum* and Daniel Palmer are with John Carroll University, Cleveland, OH, USA (*phone: 216 397-4684; [kirsch; dpalmer]@jcu.edu)

Phillip McCullick is with the Naval Postgraduate School, Monterey, CA, USA (pcmccul@nps.edu)

Ravi Vaidyanathan is with the University of Southampton, Southampton, UK (rv2@soton.ac.uk)

II. Emergence

Emergence remains a concept with which we, as a community, are still grappling to understand and define. An inspection of the existing literature yields many differing, orthogonal, or conflicting definitions. Consider this sampling:

"Emergence is what happens when the whole is smarter than the sum of the parts. It's what happens when you have a system of relatively simple-minded component parts – often there are thousands or millions of them – and they interact in relatively simple ways. And yet, somehow out of all this interaction some higher-level structure of intelligence appears, usually without any master planner calling the shots. These kind of systems evolve from the ground up."

Steven Johnson, Emergence [6]

"[Emergent systems are], *complex, self-organizing, adaptive systems* [and] *possess a kind of dynamism that makes them qualitatively different from static objects such as computer chips or snowflakes, which are merely complicated. Complex systems are more spontaneous, more disorderly, more alive than that. At the same time, however, their particular dynamism is also a far cry from the weird gyrations known as chaos."*

M. Michell Waldrop, Complexity [9]

"Emergence is when a simple set of causal rules form complex patterns when they are played out in a system. The patterns formed are not reducible to the simple set of rules that formed them, are not strongly predictable, and are usually subjectively surprising. The latter cannot be part of a rigid definition, but is what originally keyed us in to the existence of emergent phenomena."

Adam Ierymenko, "What is Emergence?" [5]

"… 'emergent' is not always a deeply explanatory label even when it is agreed on: the more complex the phenomenon is, the more intricate are the underlying processes, and the less effective the word emergence is alone. In fact, calling a phenomenon emergent is sometimes used in lieu of a more meaningful explanation."

the Lohipedia [7]

If we, as a community, have difficulty defining the concept to ourselves, it is painfully clear that an even harder task awaits us when we try to explain it to students, supervisors, research sponsors, and cross-disciplinary collaborators without a background in computer science, engineering, and/or multi-agent systems. Furthermore these concepts are of critical interest in a range of non-technical subjects whose students could greatly benefit from their instruction. Of particular

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 298–303.
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mmeybodi@aut.ac.ir

impact is the capacity to observe a tiny change to agent behavior and witness the global effect for the swarm.

III. Two Different Kinds of "Surprise"

Adam Ierymenko correctly states in his definition of Emergence [5] that since "surprise" is a subjective emotion, it has no place in a rigorous description of a phenomenon. Despite this, many definitions do include a component that attempts to express the sense of the unexpected when describing emergent systems [5,6,9]. The fundamental problem arises when parties on opposite sides of the surprise communicate. In investigating this, Bonabeau presented the Aggressor-Protector game, a multi-agent interactive "game" that follows very simple rules [www.icosystem.com/game.htm][*]. In a crowd (simulated agents), each agent picks two other agents, A and B. In the first instance of the game, an entire crowd mills about the space they are in, more or less filling it to the boundaries. In the second version of the game, which is exactly the same as the first except that the roles have been switched, produces drastically different behavior, the entire crowd compacts into a single solid mass, attempting to form a singularity near the center of mass of the original crowd. That there should be such a dramatic difference in the global behavior resulting from such a small change in local behavior is surprising to those not familiar with the field. Several papers have specifically analyzed the dynamics of this game, in particular with respect to the linkage between the low-level rule change and the global-level results.

We propose a different way of looking at the "surprise". In [2], the author defines the algorithmic content of a concept as the size of the smallest program that can produce the concept. Therefore, the algorithmic content of a program that produces π is rather small compared to that of a specific, but randomly selected million digit number. In the first case, a mathematical formula for π can be encoded and executed; in the second case, the only viable option is a print statement follow by the specific, million-digit number. Another interesting and illustrative example of this is Langston's Ants [http://www.samskivert.com/shaper/java/langston/]

Why does this behavior surprise? We propose that it results from the simulation having a much smaller algorithmic content than a direct, deterministic solution would require. Imagine writing a set of deterministic rules to produce the effects of the Aggressor-Protector game or Langston's ant. Lanston's ant, for example, seems to be the programmatic embodiment of about 10,000 random numbers followed by some regularity. The program would seemingly require hardcoding 10,000 values followed by a comparatively simple loop to produce the regular pattern. The emergence-based program is essentially three lines long. Emergence represents a "short-cut through information space", an "informational wormhole" if you will. A much smaller algorithm than seems possible can be written to produce very complex behavior. This process is not fully understood, yet it has many properties that are quite desirable. A new holy grail has become to understand and harness this process, use the short-cut to produce simpler programs to do complex things. Our understanding of it now is little more than a black box, simple things go in, and interesting, complex behaviors come out. We need rigorous definitions and better understandings of the process. To achieve this, we need more experience with bottom-up problem solving and programming agent interactions.

[*] We recommend that the reader experiment with the simulations of Bonabeau and Langston to appreciate the impact of propagation of behaviors.

IV. Existing Swarm Modeling and Simulation Tools

There are many multi-agent simulation tools available with varying degrees of sophistication, ease-of-use, and flexibility [1,2]. We briefly consider a handful for the purpose of comparison. In every case, these packages can be used to develop simulations of multi-agent systems, including a teaching application like EBST, but trying to use them directly to teach neophytes swarm concepts is a poor fit. There is too much programming, too steep of a learning curve or too little direction towards bottom-up design concepts

A. Swarm

Swarm is a very sophisticated simulation tool based on hierarchical swarms that has a learning curve commensurate with its power. Using the system requires knowledge of object-oriented (OO) programming concepts, an OO language (Java, ObjectiveC), and some Swarm syntax. Its intended purpose is to build complex multi-agent simulationsas tools for further investigations. www.swarm.org

B. RePast

In many ways, RePast is similar to Swarm. It is java-based and requires OO programming knowledge to use. It is also intended for developing complex simulations to support other efforts. Neither of these systems is suitable for people unfamiliar with programming. *repast.sourceforge.net*

C. StarLogo and its variations (NetLogo).

These languages are based on an earlier language, Logo. With children as the indented audience, it was designed to be very easy to use. The multi-agent variations embrace that design principle. The programming that is required is procedural in nature and not an obstacle for those with limited programming knowledge. StarLogo can easily produce slider bars and buttons to control the generated simulations. Both Logo variants are programming languages and as such are open ended in terms of application. A layperson, however engaged by the easy-to-use interface, could interact with the system indefinitely without stumbling upon, and gaining insight into, key bottom-up design issues. www.media.mit.edu/starlogo

V. Emergent Behavior Simulation Tool

Our goal with the Emergent Behavior Simulation Tool (EBST) is to have the layperson jump right to the key issues and grapple with them. EBST is not a general programming experience; it is not a programming language that can develop general multi-agent simulations. Rather it is a collection of specific scenarios that are straightforward to understand, that require expressing logic to resolve, but does not require any syntax or traditional programming knowledge to use. Like

mmeybodi@aut.ac.ir

AgentSheets, all programming is done visually via dragging and dropping icons, prioritizing actions with radio buttons, indicating initial conditions with check boxes and slider bars. The "output" of the program is an animation of the programmed agents, following their instructions, interacting with each other. The key benefit of this system is the quick feedback loop between telling an agent what to do and immediately watching a swarm of them interacting, followed by telling them to do something else. EBST tightens the connections between agent actions and swarm behaviors, and illustrates the nature of probabilistic programming.

A. Modeling agent behavior – the Model page

Instead of syntax driven programming, EBST uses a drag and drop, visual interface that implements a finite state machine to control an individual agent (see Figure 1). The FSA consists of states and transitions between states (see Figure 2). The states correspond to actions that an agent can take, and the transitions represent sensors that trigger based on internal or external stimuli. When a sensor detects some change, the agent can transition into another state, taking a new action in response. There can be neither syntax errors nor compilation problems. The interface only allows the development of correct "programs". The FSAs can be saved, restored, and easily modified using the mouse. The FSA model is intuitive

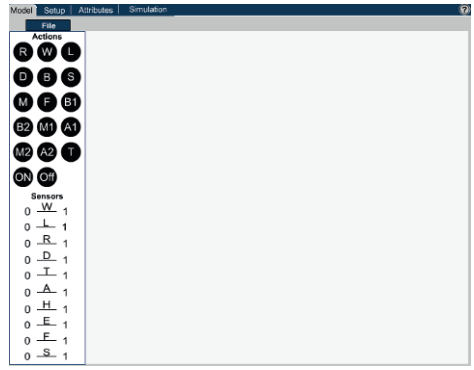


Figure 1 Model Tab – A canvas on which to build an FSA using states and transitions in the left margin. All transitions can be split to multiple destinations, each with a user assigned probability

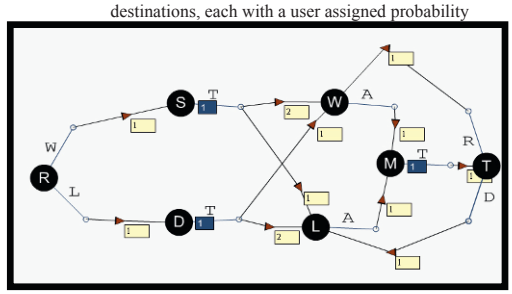


Figure 2 Example FSA – A seven state FSA with simple and probabilistic transitions. Each state may appear only once per FSA, transitions can occur once per state

B. Prioritizing sensor input data – the Setup page

When multiple transitions lead from the same state, it is possible that more than one of the triggering events can occur simultaneously. To resolve ambiguity, the user must specify a priority ranking of all transitions. In EBST, the prioritization is specified with radio buttons (see Figure 3). This interface prevents any sensors having the same priorities and forces every one to have some priority.

Priority ordering is critical in determining the resulting behavior of the agents. Consider the following situation: an agent searches for a bright location when it is low on energy to recharge its solar battery, but it also must avoid drop-offs that could cause damage. If an agent has three sensors: low energy, in brightness, and near edge, it is easy to imagine a set of priorities that could prevent the agent from recharging or cause it to fall off an edge when it needed to recharge. It is very enlightening to keep the FSA the same and just change the priorities of the sensors and observe the different types of behaviors produced. This is particularly important in demonstrating to the layperson the sensitivity of the swarm's behavior to small variations in the agents' actions.

Normally, it is not necessary to fully order the priorities. Often a partial ordering is sufficient to resolve any possible conflicts. However, even if the user only cares about the relative ordering of only two sensors, by virtue of the radio button interface, all other sensors will have a default priority.

C. Varying the Initial Conditions – the Attributes Page

Multi-agent simulations have lots of system parameters and initial conditions that affect the swarm's performance. A quick and simple way of altering them is to use slider bars (see Figure 4). They are very intuitive, provide visual feedback, as well as implicit range information, and anyone who has ever played a CD on their computer has used one before. Some scenario characteristics (number of agents, length of the simulation) are always present. Other, scenario specific values can be included as needed.

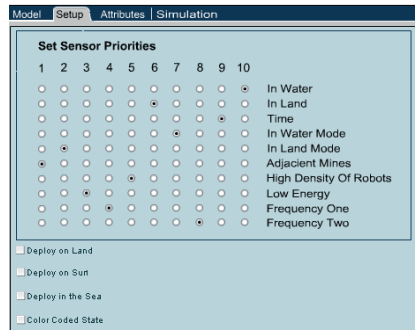


Figure 3 Sensor Priorities – If multiple transitions are true, the one with the highest priority is used. The user sets the priorities with radio buttons.

In some instances, costs can be associated with the characteristics represented by the slider bar. In those cases, the unit cost is presented with the slider bar and the total cost is

mmeybodi@aut.ac.ir

calculated.

Introducing costs is critical for later evaluation of possible design trade-offs. Even in a rudimentary form, a limited budget forces serious consideration of design alternatives and algorithmic choices. In challenges to students, a fixed budget amount can force a selection between the level of robot sophistication and how many of them to apply.

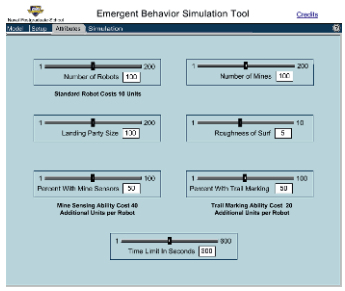


Figure 4: Initial Conditions – Multiple slider bars set parameters for a scenario. They can make the challenge incrementally more difficult, requiring a deeper understanding of the problem and a more reasoned set of responses.

D. Observing the Interactions – the Simulation Page

The simulation page has color coded, animated play/pause interface for viewing the results of the agent-level programming. In the current version of EBST, there are three different teaching scenarios: Ants Build Bridges; Ants, Bridges and Food; and Surf Zone Mine Sweeping Swarm (see Figures 6,7, and 9). The page simply consists of a PLAY, PAUSE, and RESET button, a status bar, and a large canvas on which the interactions of the recently programmed agents play out. The status bar includes general information such as the time of the simulation, and then scenario specific information such as "the number of ants still alive", and "the total cost of the robotic swarm". In all three scenarios, there is also a performance metric to compare different agent designs.

Some of the most engaging experiences using EBST have been to leverage its obvious video game characteristics and pit the students against the class. By keeping the "high score" posted, students will become engrossed trying to outdo one another. (Note this works equally well with undergraduates and technical professionals).

E. Interacting with the Tool.

For quick access, all four pages are available through tabs at the top of the interface. This allows users to instantly respond to unexpected observations on the Simulation page, by flipping back to the Model page, make a change to the FSA, and return to the Simulation page ready to run again. Switching between tabs automatically resets the Simulation page, so no effort is necessary to tear-down a previous simulation before starting the subsequent simulations.

VI. Bottom-Up Design of Swarm Behaviors

At this time, we have implemented three swarm scenarios for simulation in the EBST. The fundamental agent behaviors are similar in all cases. Though all three scenarios are based on existing multi-agent situations, the goal is *not* necessarily to accurately portray them. For the purposes of learning about bottom-up design of multi-agent systems, having a real concept underlying the scenario is sufficient. The first two scenarios abstractly model the bridge building and searching behavior of certain of ants; specifically, Eciton burchelli (see Figure 5).



Figure 5 Army ants (Eciton burchelli) form bridges with their bodies. This is the conceptual basis for the first two EBST Scenarios [Photograph by Alexander Wild, www.alexanderwild.net].

A. Ants and Bridges

This first scenario is the simplest, and primarily used to familiarize the user with the EBST interface and system. There are only four states and three sensors, yet it immediately presents the swarm neophyte with a fundamental agent based programming problem. The goal is to have the ants build a bridge across the gap with their bodies. Once the ants find the edge, they can start building a bridge by extending their body out into the void with the expectation that subsequent ants will climb on and further the bridge's construction. The problem is that every agent has the same set of instructions, so quickly most of the available ants begin their own bridges and the few bridges that do gain additional ants, infrequently have enough to cross the gap.

After experimenting a bit, most students come to recognize that probabilistic transitions to limit the number of bridge starters will better apportion the ants.

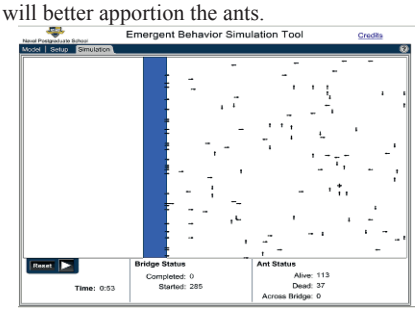


Figure 6: Ants and Bridges Scenario – The swarm of ants attempts to make a bridge of their bodies across the gap by climbing on each other. The goal of the scenario is to simply get ants to the other side in the shortest time possible.

B. Ants, Bridges, and Food

The next scenario builds on the first, by introducing additional actions, sensors, goals and obstacles. Now, the ants get hungry. There is food available, but the user has to balance the two separate goals of building a bridge and not starving. This addition introduces critical priorities which must be expressed before the scenario runs. The ants also have to reach their home on the other side of the gap, creating a third goal. The goal cannot be found before the ants build a bridge, but there is also no point in building a return bridge once an ant crosses. Yet, there is only one "wander" state, and the ant needs to wander on both sides of the gap. Thus a careful

mmeybodi@aut.ac.ir

balancing of sensor priorities, appropriate probabilities, and judicious use of the states is required.

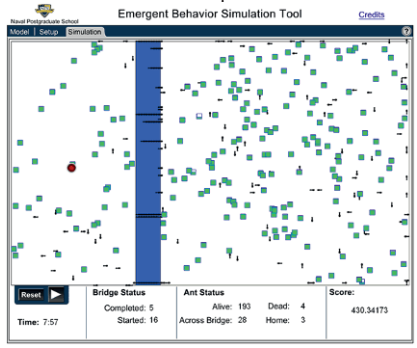


Figure 7: Ants, Bridges and Food Scenario – Though similar to the previous scenario, this one has the added constraints and time pressure to the ants requiring food. They can starve, and the amount of food is limited. Also, once across, the ants must find their nest entrance.

To help address these issues, this scenario has an additional four states and 4 new sensors – all related to food, shelter (goal), and communication. The communication is critical. In the first scenario, there is no explicit communication, only the stigmergy of finding an ant that is extending across the gap. For interesting swarm behavior, it is necessary and desirable that the agents communicate. It also introduces lots of issues for the swarm beginners to work with, including: simultaneous broadcasting, listening out of range, deciding the duration of broadcasts, etc.

C. *Robotic Mine Sweeping*

This scenario is based on work done at Case Western Reserve University and the Naval Postgraduate School on developing robots with multiple modes of mobility [1]. Again, our goal is not to accurately simulate the robots, but rather use the concept of these robots to produce a swarm programming challenge[†]. After completing the first two parts of the EBST, the users of the tool can no longer be called true beginners, and are prepared for a full-blown swarm programming challenge.

The simple interface is the same, there are just more pieces. Complexity comes directly from the swarm components. There are 17 states and 10 sensors. The goal is specific: allow a landing party at the beach cross the minefield with as few casualties as possible, but the ways to achieve the goal are many and varied. The new tools to reach that goal include an additional frequency on which to communicate, the ability to leave visual trails on land, a sensor to detect crowded regions, the means to switch modes of mobility, and the ability to detect a mine without detonating it. (These last two abilities have additional costs associated with them.)

[†] In future work we expect to evolve this simulation into a toolbox for a force commander to rapidly deploy such robots in amphibious environs. Parameters for the simulation will be modified to reflect actual robot performance as hardware testing for the robots matures.



Figure 8: Surf Zone Mine Sweeping Scenario – Autonomous robots with multiple modes of mobility serve as the inspiration for this scenario. Members of our team are developing such robots that can operate in both land and water and switch between the two modes dynamically

In this task, the user experiences swarm design trade-offs. Is it worth the extra cost to equip all robots with mines sensors, or only some if their marking ability is managed properly? Does a robot have enough power left to make switching mobility modes at a cost a worthwhile investment? What is the best way to use the limited resource of two communication frequencies without producing undesirable side-effects? This scenario is a leap up in complexity, but this is where the benefit is realized. The user begins to really see the constraints and benefits of a decentralized approach. After they have been through this scenario and its challenges, vague social insect analogies won't be necessary as former neophyte stakeholders and swarm researchers can speak the common language of the concepts and examples in EBST.

VII. Bottom-Up Design Concepts

A. *Probabilistic Programming*

Programming a swarm by dictating agent action requires a level of indirection that can lead to "surprising" behaviors. (Consider the Aggressor-Protector game or Langston's ant.) The idea that simple rules can lead to unexpected results means that programming by this mechanism can be very tricky and debugging is frequently reduced to trial and error. Key stakeholders must understand these difficulties and must be able to discuss them. An important step in this direction is for them to put aside any notions of deterministic instructions and become familiar with probabilistic programming.

All three scenarios in EBST convey this idea, but the first, in its stark simplicity, introduces the idea in a strong, visual way that makes an impression and it lays a foundation for the next two scenarios.

B. *Benefits and Complexities of Heterogeneous Swarms*

In the Mine Sweeping scenario, four different types of agents can be introduced, by changing the slider bars related to robots characteristics. The behavior of the swarm is greatly affected by the presence or absence of the different types of robots. One of the characteristics is whether a robot can sense a mine or not. With even just a few robots with this capability and the subsequent cascading effects, the approach to mine clearing is completely different than with a fully oblivious swarm.

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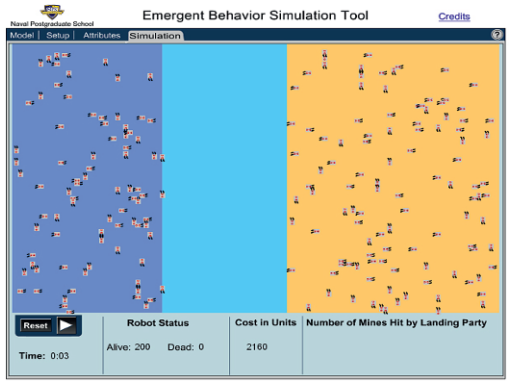


Figure 9: Surf Zone Mine Sweeping Scenario – Collectives of amphibious robots are deployed in user specified regions on a mined shoreline. The robots must, through many available options, make safe passage from sea to shore possible for a user-specified landing party. Note the deep water (left), shifting surf zone (center), and beach environs (right), all of which force the emergent architecture to adjust, reinforcing the nature of complex adaptive systems.

The interesting problem facing the user is how to mange a swarm with different types of robots. In EBST, one FSA fits all – there is no option of programming some robots differently than others. Therefore, one FSA must handle all possible conditions. When the FSA specifies an action that requires a mine sensor if the robot does not have one, it ignores the instruction. This leads to considering the cost of the sensors in comparison with the benefits derived from them.

C. *Cost-Benefit Trade-offs*

By considering the total cost of the swarm and the performance metric of mines encountered, different approaches can be directly compared. It may turn out, that performance improves as the number of agents with mine sensors increases up to half and then flattens out. This type of question plays out in many contexts throughout the EBST. Because the scenarios are designed for experimentation, users can gather supporting data for proposed trade-offs. The scenarios are simple enough, the parameters are few enough, and the metrics are specific enough to actually determine whether a particular approach is better than another. This type of analysis is often exactly the kind of information of interest to stakeholders.

Note "cost" here does not necessary translate into dollars, it could also mean doing one thing instead of another with limited resources. If two differently-equipped swarms could successfully sweep the surf zone, then it is far better to have the less equipped swarm do the task in anticipation of better overall use of the available resources.

D. *Balancing Multiple, Conflicting Goals*

When upgrading from the "Ants make bridges" scenario to the "Ants, bridges and food" scenario, the user realizes that they cannot concentrate on one, single-minded task. You've got to eat too. In the field, there are many factors that must be considered at all junctures - far more than in these scenarios. But the act of having to juggle two gives a greater appreciation for the constraints of having to de-conflict several.

VIII. Summary and Conclusions

The Emergent Behavior Simulation Tool is presently the centerpiece for an online course being developed for military force commanders at the Naval Postgraduate School. An earlier incarnation of the system has been tested and evaluated at both the Naval Postgraduate School and John Carroll University. The system has also been used at the Navy War College in Rhode Island. Feedback from all three groups of testers has been folded into the latest version of the system. In all instances, users expressed interest with the tool and found the video game-like aspects engaging. Furthermore, nearly all users have definitively stated that decentralized emergent concepts were elucidated with far greater clarity through the interactive experience of the build/experiment/modify cycle for successful task execution.

IX. Acknowlegements.

The authors would like to thank Sherrill Meaney, Tom Hazzard, and Capt. (ret.) Jeffery E. Kline at the Naval Postgraduate School for their support on this project. We are also grateful to the undergraduate students at John Carroll University in classes CS 280, and CS 467 for their interest and efforts using the program. They found some bugs, and gave us some good ideas for the next release. Finally we would like to thank all students in the Navy War College class "Analytic Tools for the Warfare Commander" who participated in the testing and use of the EBST.

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mmeybodi@aut.ac.ir

Students' Self-management: E-Course, E-Tutoring and Online Support System

Mare Teichmann
Tallinn University of Technology, Estonia
mare@pekonsult.ee
Jakob Kübarsepp
Tallinn University of Technology, Estonia
Jüri Ilvest Jr.
PE Consult Ltd., Estonia

Abstract: **This paper discusses designing of an E-course and the Students' E-tutoring and Support System (the SEOS System) at Tallinn University of Technology (TUT). There was a pressing need for such a system since the student drop-out rate at TUT is high (40%), especially among the first-year students. The general purpose of the E-course "Self-management" and the SEOS System is to decrease the drop-out rate among first-year students through individual assistance in problem solving. The first steps were interviewing tutors and doing a Pilot Study in order to map the problems first-year students have at TUT. We designed and introduced the self-management E-course since it became evident that students at TUT often had problems that fell outside the scope of TUT student support sources such as problems concerning knowledge and skills of time management and personal finance management. The SEOS System was developed for decreasing the first-year students' drop-out rate trough offering them individual assistance, advice and guidance.**

I. INTRODUCTION

TUT is the second largest university in Estonia; it is also the only university of technology in Estonia providing an interdisciplinary higher education and technological advancement. TUT have over 11,000 students. About 1,500-2,000 new applicants a year have been accepted in recent years but very many of them find it difficult to cope and, therefore, drop out. About 40% of TUT first-year students drop out of university; the drop-out rate is especially high in engineering faculties. There exists a growing body of evidence that the first-year students' drop-out rate has reached a critical point in many universities as more students drop out than graduate [1; 11]. The ongoing debate about the first-year students' drop-out has shown that the decision to persist in or leave university is affected by multiple factors interacting in a cumulative way. Researchers, however, are mainly interested in the different predictors of students' drop-out [5]. In recent years, there have been some interesting studies focusing on two predictors of students dropping out of university, namely, poor skills of time management and financial management. Leonhard F. Bernold [2] established that problems with poor time management were listed by 25% of the freshman cohort at the end of the first semester. The idea that students' drop-out is predictable by student time management has been tested but findings have been somewhat inconsistent. Some empirical findings suggest that there exists a strong relationship between students' skills of time management and them dropping out [3]; other researchers are more sceptical [9]. Studies have shown that students have inadequate knowledge of personal finances and fail to make correct decisions because they have not received a sound personal finance education. The notion that there exists a causal relationship between students' money management knowledge and dropping out is wildly accepted. For example, Pru Marriot's [7] findings demonstrate that 34% of students have difficulties in balancing their finances and it indicates significant gaps in their personal financial knowledge. Moreover, Angela P. McGlynn [8] points out that poor skills of financial management are a leading cause of dropping out. Highlighting the fact that many academic institutions provide support to increase the financial awareness of students so that they can better manage their personal finances, we designed a self-management E-course for students aiming at improving their time management as well as personal financial management knowledge and skills. It was important to create the Students' E-tutoring and Online Support System (the SEOS System) in order to put all sources of student support at TUT into a proper perspective.

II. PRELIMINARY WORK

Various studies aimed at establishing the causes of first-year students dropping out by analysing their problems were conducted in order to work out the SEOS System.

A. Examination of tutors

Tutors at TUT are volunteers from among senior students who assist first-year students in familiarizing themselves with student life, cope better and become adapted. 56 tutors filled in the questionnaire and thus pointed out the most common problems of first-year students.

B. Pilot study

The pilot study was conducted *via* the Internet*;* 243 students participated in the study recalling three most burning problems they had in their first year and how they solved the problems.

C. Analysis of freshmen's problems

The tutor interviews and findings of the pilot study enabled the authors to map the problems of first-year students at TUT. Depending on the organisational support provided by the university (tutors, the staff of deans' offices, the academic

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 304–308.
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mmeybodi@aut.ac.ir

staff, career counsellors, psychologists etc), we divided the problems of first-year students into four categories:
a) Studies: problems related to the organisation of studies/the curriculum (organisation of studies, the study process, a subject or a member of the academic staff). For example, the university curriculum is not harmonised with the secondary school curriculum – the level at university is somewhat higher than at secondary school; a high number of extensive and relatively complex subjects are taught during the first two semesters; all tests are scheduled for the same week (they are at a similar interval; high speed – the lecturer rushes through the lecture or seminar and keeping up is the student's problem etc.
b) Factors supporting studies: living conditions, education allowances, loans, grants, spare time, sports, health problems. For example, financial problems, working simultaneously with studying, finding a suitable job, health problems, special needs etc.
c) Psychological problems: for example, relations with fellow students or members of the academic staff, personality problems, motivation problems, difficulties with adapting, over-organising one's activities (too many activities), falling in love, etc.
d) Problems with career planning: for example, randomly chosen profession, insecurity, doubts whether the chosen profession is the right one, wrong profession and disappointment, choosing the right subjects in terms of the future profession and planning one's career etc.
The analysis of the first-year students' problems demonstrates that there exists the so-called no man's land at TUT. In addition to the above four categories, students listed a number of problems solving of which was outside the scope of the student support sources at the university; the problems related mostly to students' needs for acquiring new knowledge and skills to cope on their own. This confirmed the need for a self-management E-course.

III. DEVELOPMENT OF E-COURSE

A. Course Content

The course content reflects the TUT students' need to improve their knowledge and skills for successful coping at university. The course provides more knowledge in time management and support for students in increasing their financial awareness, gives them guidelines for effective learning and coping with stress (Fig. 1).

B. Content Outline

The self-management E-course consists of an introductory lecture (the 0-lecture of the E-course "Self-Management), that was conducted as an ordinary academic face-to-face lecture later added to the Web environment (Fig.2.), and of six different Digital Teaching Tools available *via* the Internet:
1. Self-management: personal objectives, frustration, decision-taking and responsibility, problem solving, success, establishing priorities [6], motivation, personality and self-esteem, emotion management, conflict resolving (http://deepzone2.ttu.ee/hhp0020/ej/ej1.htm)
2. Time Management (Fig.3.): time management, value of time, four levels of time management [4], techniques of prioritizing (http://deepzone2.ttu.ee/hhp0020/ej/ej2.htm)
3. Students' Personal Finance Management: decision-taking, conflict of motivation, objectives, expenditure, revenue, the loan, credit, the credit card (incl. compound interest), needs, quality of life [10], happiness (http://deepzone2.ttu.ee/hhp0020/ej/ej3.htm)
4. Study skills: the academic lecture, the practice session, the seminar, independent work, before an examination, attention, memory, thinking (http://deepzone2.ttu.ee/hhp0020/ej/ej4.htm)
5. Stress: stress dynamics, work-related stress by professional groups, types of stressors, burnout, stages of burnout and first aid, type-A personality or workaholic, coping with stress, balance of personality, social support, stressors of students at school, (http://deepzone2.ttu.ee/hhp0020/digi/stress.htm)
6. Coping with stress: coping with stress, coping, coping and problem solving, coping and emotions, escape strategy, assessing the situation
(http://deepzone2.ttu.ee/hhp0020/digi/toimetulek.htm)

C. Course Design

All six digital teaching tools of the self-management E-course are available for all first-year students *via* the Internet (http://deepzone2.ttu.ee/hhp0020/ej.php).

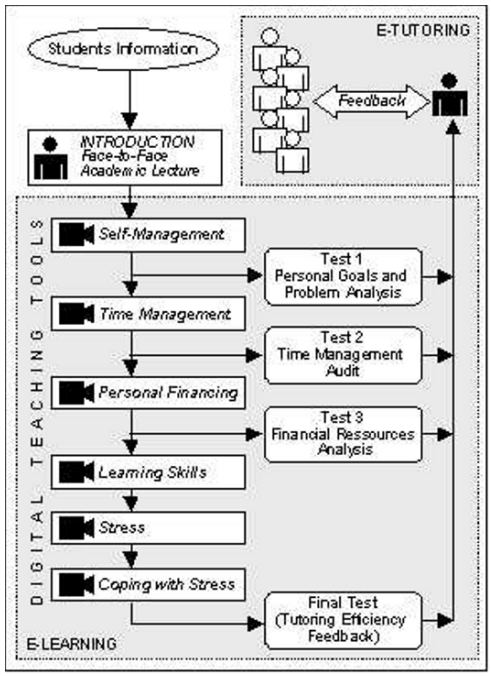


Fig.1. E-Course Design

The self-management E-course (1.0 ECTS) consists of six different Digital Teaching Tools as well as of e-tutoring with a member of the academic staff and of three independent credit

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assignments (an analysis of personal objectives and problems, a time management audit and a financial resources analysis).
Each Digital Teaching Tool consists of

- A video-based lecture
- The slides shown during the lecture
- Some written material for student reading
- An MP3 audio version of the lecture
- A DVD version of the lecture.

The course is to be primarily used in the web environment although both the options of an MP3 and a DVD version are included.

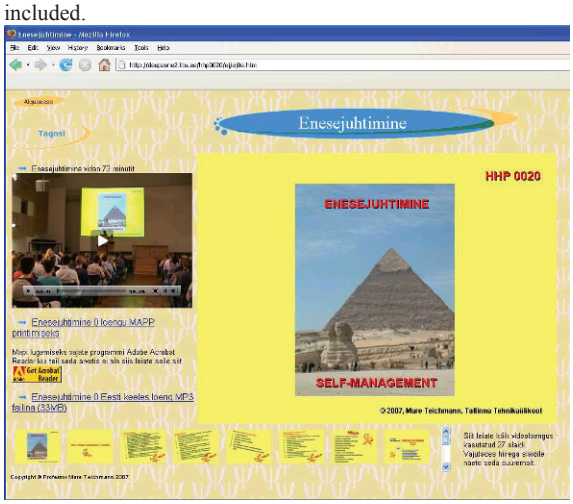


Fig.2. The 0-lecture of the E-course "Self-Management" (http://deepzone2.ttu.ee/hhp0020/ej/ej0e.htm)

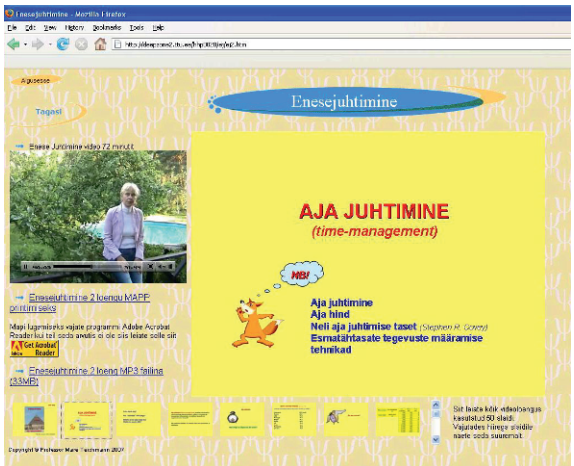


Fig.3. E-course "Self-Management", the Digital Teaching Tool "Time Management" (http://deepzone2.ttu.ee/hhp0020/ej/ej2.htm)

D. Architecture

The system was built using PHP implementations for developing and running distributed architecture. We preferred PHP implementations for several reasons. First, they are platform-independent, e.g. it is a model of software that is independent of the specific technological platform used to implement it. Second, an advantage of PHP is that it is possible to get started with little or no cost. Third, video streaming is of little burden to the server. Forth, it allows necessary flexibility in usage of the digital teaching tools and developing them as a means of E-learning. Videos are streamed with PHP Streaming and played with the Flash Video Player by Jeroen Wijering. Both scripts can be downloaded for free for non-commercial use. The student texts are available in the PDF format and students can download Adobe Acrobat Reader for free.

E. Textbooks

There is a plethora of popular literature addressing the issue of young adults coping with independent life. Many books are designed for specialists and require specific knowledge, e.g. of economy. We listed two books as recommended reading:

- M.E. Haynes, "Personal time management", USA: Thomson, 1994.
- D**.** Allen, **"**Getting Things Done: The Art of Stress-Free Productivity", (in Estonian), Tartu, Estonia, Väike Vanker, 2007.

F. Testing, E-tutoring and Feedback

The purpose of the credit assignments is to maximize the critical thinking skills of students and teach them practical problem solving and decision making skills on the basis of their own goals and problems. The assignments are submitted *via* the Internet; the lecturer comments and gives feedback on each assignment also *via* the Internet.
In order to pass the course, the student is required to do three practical skills oriented credit assignments:
1. Establish their own three most significant priorities in the given academic year and three most significant problems by employing the Kepner method for establishing priorities;
2. Conduct a personal time audit, i.e. observe, take notes of and analyse their own use of time over a period of two weeks and establish instances of wasting time to be avoided in future;
3. Make an analysis of his/her personal financial resources, i.e. a) take notes of and analyse his/her spending and income (expenditure – revenue), b) analyse their current financial position, c) set their financial priorities, d) determine their net worth, e) determine their income and expenses, and f) set up a recordkeeping system.

IV. DEVELOPMENT OF SEOS SYSTEM

A. Freshman Test

The freshman test (Fig.4.) was drawn up based on the analysis of the problems TUT students have. It is a questionnaire consisting of 75 questions. All responses are on a 6-point Likert-type scale. The anchors are "very definitely not a problem" (1 point) and "very definitely a problem" (6 points).

mmeybodi@aut.ac.ir

Each block of questions has an open area for comments and problems not addressed in questions. Two additional questions were added on gender and student book number; thus, the test is not entirely anonymous as students can be identified on the basis of their student book numbers and contacted if necessary.

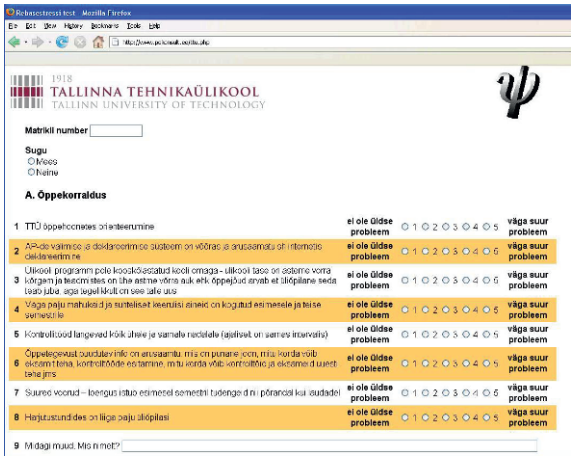


Fig.4. Freshman Test (http://www.pekonsult.ee/ttu.php)

All 505 students who sat the test were first-year bachelor's students; they completed the questionnaire voluntarily and without compensation.

B. SEOS System

The SEOS System is developed for decreasing the freshman dropout trough helping them solve their problems by offering them individual advice and guidance.

The freshman test is available in the web environment where the student answers the questions (Fig.3.). The user's answers are screened and a weighted score for each problem is automatically calculated in the web environment. The result in the form of Behavioural Guidelines (Instruction or Feedback) automatically appears on the screen once the user pushes the button "CLICK HERE TO VIEW THE TEST RESULTS". The data is then removed from the web environment since according to the test manual the saved test results are copied into and kept in a database outside the web environment. This ensures the data are not violated and the confidentiality of the user's test results is guaranteed (Fig.5).

For example:

i) The positive scenario – if the first-year student has no problems, he/she receives feedback in the form of Behavioural Guidelines Feedback wishing him/her every success with his/her studies.

ii) The negative scenario - if the first-year student has problems, he/she receives feedback in the form of Behavioural Guidelines Instruction suggesting possible solutions to his/her problems, i.e. where to go and whom to contact in order to get help or advice; contact data of the appropriate people (their e-mail address, telephone number, location at TUT and room number) are also included in the Instruction.

Examples of Behavioural Guidelines (Instruction):

- The student has problems choosing appropriate course materials – He/she is advised to a) contact the lecturer conducting the course; b) consult with librarians; c) consult with senior students; d) consult with his/her fellow students taking the same course.
- The student has problems with time management - He/she is advised to a) use the Digital Teaching Tool "Time Management" of the self-.management E-course; b) conduct a personal time management audit and analyse the findings.
- The student has problems with self-esteem (insecurity, can I cope?) – The student is advised to a) see a psychologist; b) consult with TUT career counsellors.

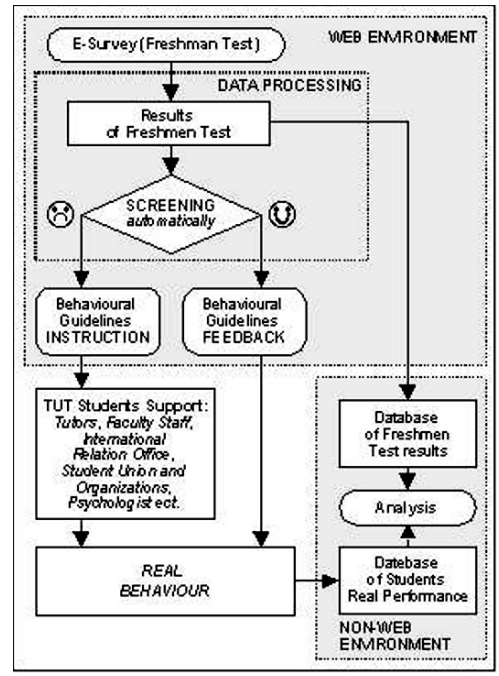


Fig.5. Students E-tutoring and Online Support System (SEOS System)

Freshman test results can be compared with students' real performance (grades) in a TUT database. Such an analysis enables us to assess the effectiveness of the SEOS System.

C. Architecture

The system was built using PHP implementations for developing and running distributed architecture. SPSS is used for archiving the database and for statistical analyses of the data. The freshman test results' processing script is the modified version of the data processing programs of our earlier psychology tests (Occupational Stress Indicator-2, WHO Quality of Life-100, Work-Family Conflict Scale etc.).

mmeybodi@aut.ac.ir

V. CONCLUSION AND FUTURE WORK

The self-management E-course and the SEOS System were launched in autumn 2007, and were an instant success with TUT students. 505 TUT first-year students registered for this optional course (close to 30% of the first-year students accepted at TUT this academic year). All the students who registered for the course took the Freshman Test and received personal Behavioural Guidelines (Feedback or Instruction) assisting them in problem-solving. Problems are analysed and compared to the students' real behaviour after their first examination period.

However, the most important outcomes were the self-management E-course and the SEOS System as instruments for decreasing the students' drop-out rate in their first year of studies.

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mmeybodi@aut.ac.ir

E-Learning Promotes Information Security

Dr. Margareth Stoll,
Margareth.stoll@dnet.it
O&ICT,
EURAC Research
Drususallee, 1
Bozen, South Tyrol, Italy

Economic globalization, extensive use of IT-systems, the always stronger competition and severer legal regulations requires increased data protection, availability and data integrity. Therefore always more organizations are implementing an information security management system regarding ISO/IEC 27001 and ISO/IEC 27002. Such standard based management systems (as information security ISO/IEC27001, quality ISO9001, environmental ISO14001, hygiene management systems ISO 22000, IT service management ISO/IEC 20000-1 and others) are widely implemented and based on common principles: objectives and strategies, business processes, resource management and continuously optimization. These systems must also be documented (system documentation), communicated, implemented and continuously improved. Thereby the collaborators awareness is the great challenge and chance. The elaborated organizational regulation contains all relevant information security requirements adapted to the organizational needs and objectives. Normally these are elaborated one time, trained, distributed, but are hardly used as reference book for workplace need-oriented process integrated learning to improve information security. The documentation is almost felt as additional workload with a little or no advantage and it is not totally corresponding with the lived principles.
Based on this situation we prepared the system documentation according to media-pedagogical and didactical principles and published it on organizational learning and knowledge system based on constructivist theory. In the case study the documentation promotes in a confidence-based, open and fault-tolerant corporate and learning culture workplace integrated, need-oriented access to the documentation, improvement of information security, employee involvement and knowledge sharing, a practice-oriented system documentation, shorter initial training periods for new collaborators and thereby a continuous optimization of information security and the organization.

Keywords: information security management, data protection, management systems, e-learning, workplace learning,

I. Introduction

A Starting Situation

About 3879 [1] organizations of different sizes and scopes are implementing already since several years an information security management system regarding ISO/IEC 27001 and ISO/IEC 27002 are based on international standards with following principles: organization information security objectives and strategies, information security in the business processes, resource management and continuously optimization of the information security. The established management system must be documented, communicated, implemented and continuously improved.
The need of developing an integrated, the organization adapted system solution and the shift to holistic management systems influenced the integration of information security, knowledge management and other relevant aspects for the organization by integrating different management systems, as quality ISO9001, environmental ISO14001, hygiene management systems ISO 22000, IT service management ISO 20000-1 and others to a single, interdisciplinary, holistic the organization adapted management system. Thereby the system documentation contains all organizational regulations and interpretations of legal requirements to supports the knowledge distribution for promoting the knowledge implementation by establishing a basis for the knowledge generation.

B Purpose of the article

The documentation of this standard based management systems (system documentation) was distributed for long time as books, whereby the collaborators received one-time the information and used them afterwards for possible questions scarcely ever. In the last ten years the system documentation was distributed more electronically through web-based intranets, document management platforms or as pdf. The delivered system documentation is in theses way used a little more as reference book for solving ad hoc learning needs. But changes proposal are not related to the documentation and the collaborators are not able to discuss new ideas or questions in a context-sensitive way. The change and improvement processes of the management system are isolated from the documentation.
Therefore the primary use of the system documentation is as a tool for the system introduction and afterwards it is primarily for the auditor to fulfill the standard requirements. It is usually changed only once a year, if at all and it frequently does not correspond to lived processes. Moreover in addition to it instructions and forms are developed as hidden system.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 309–314.
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mmeybodi@aut.ac.ir

C Research approach and structure of the article

Economic globalization, extensive use of IT-systems, the always stronger competition and severer legal regulations requires increased data protection, availability and data integrity and the great importance of the system documentation as base for information security management leaded us to the extension of a constructivist learning platform as an organizational learning and knowledge system [2], [3] for distributing the system documentation of an integrated standard based management system (ISO/IEC 27001, ISO 9001 quality management and knowledge management) in accordance to media-pedagogical and didactical principles.

Firstly we illustrate the requirements of ISO/IEC 27001 information security management within a holistic standard based management model regarding the main principles of standard based management systems [II] and based on the starting situation we describe the project objectives [III]. Afterwards we present our approach [IV] including the requirements for an organizational learning and knowledge system [IV A] and the success factors [IV B]. Finally we document the project experiences and results of the implementation in different organizations with distinct management systems [V] including the achievement of the project principles [V A] and a reflection about cost and benefits [V B] and at the end we express an outlook [VI] and our conclusion [VII].

II. Main Requirements of Standard Based Management Systems

The ISO/IEC 27001 information security management is more frequently implemented in a holistic way. In accordance with the organizational purposes and objectives are integrated in a single holistic management system different aspects like quality, environment, hygiene, data security, occupational health and safety, as well as personnel development, resource management, IT - management, communication management, controlling and also knowledge management. Therefore we present the common principles of holistic standard based management [4], [5]:

- Organizations objectives and strategies with the focus of the considered standard must be established regarding customer requirements.
- All activities and processes including management process, support processes, resource processes and optimization processes must be defined and promote the optimized fulfillment of the organization objectives under the focus of the respective standard. Additional the ISO/IEC 27001 requires a risk assessment as basis for the definition of processes and organizational regulations (work instructions, legal construction, and others).



Fig. 1. Main requirements of standard based management systems

- Process oriented resource management must be promoted including personnel development and other infrastructures, tools and instruments.
- The organization and their objectives and strategies must be continually optimized according to established processes in sense of a PDCA cycle (plan, do, check, act).

The established management system must be structured and systematically documented and communicated within the organization and the collaborators must be continually motivated for implementing the system and for recommending improvements.

III. Project Objectives

How can the system documentation be modified and communicated to promote information security and to be considered, used and improved as need-oriented reference book?

By preparing the system documentation in accordance to media-pedagogic and didactical principles and implementing it on an organizational learning and knowledge system by extending a constructivist learning system we expect to foster:

- workplace integrated, need-oriented access,
- improvement of information security,
- employee involvement and knowledge sharing,
- practice-oriented system documentation,
- shorter initial training periods for new collaborators,

Thus the establishment of documentation, communication, training, implementation and operating including the necessary awareness, the improvement by means of collaborators ideas, questions and discussion contribution should be optimized and the organization will be promoted in achieving its objectives including information security objectives.

mmeybodi@aut.ac.ir

IV. Approach

Firstly the system documentation must be established. Considering the needs and expectations of all interested parties we establish the organization policy with consistent strategies and goals integrating information security and knowledge objectives and plans [6], [7].

Afterwards the relevant information security risks and the organization asset are identified, the possible impact of the risk is analyzed and evaluated, options for the treatment of the risks are analyzed including control objectives and controls and the management approves the proposed residual risks. The treatment of the risks including processes, working instructions and organizational regulations are established bottom up by interviewing the collaborators involved and by integrating knowledge management and optimized in accordance with the objectives. For the holistic approach we analyze all relevant processes of the organization regarding information security aspects. The applied process modeling method defines regarding the organizational objectives and the legal and normative regulations for all activities the responsible function, the necessary documents, information, tools and it – applications. Thereby all responsible for the establishing, generating, changing, handling of the documents and data, all needed access rights and data protection activities, the external document and data sources and receivers, further the archiving procedures including duration and necessary information security regarding document logistic and data protection are determined.

The necessary resources, tools, instruments, trainings required for achieving the objectives and for improving the whole management system including information security must be identified, made available and continually optimized. Also the training and human resource development processes must be optimized and established.

The organization must also plan and implement the monitoring, measurement, analysis and optimization processes needed to continually improve the controls and the effectiveness of the management system and information security. Thus also knowledge management must be integrated and their improvement must be structured and systematically planned [8], [9], [10].

The entire system documentation must correspond with the lived processes [11]. All improvements or changes must be approved by the involved collaborators, documented, communicated and implemented.

After the development of the management system documentation, it must be prepared regarding media-pedagogical, motivation-psychological and didactical principles [12]. According to these principles it must be divided into small modules, which must be typecasted and functionally well structured. Thus, we use a constructivist method for organizing the content. In order to support the collaborators need-oriented workplace integrated access, the way for accessing the single modules should be as short as possible, optimal structured and practice oriented. All needs and expectations of the collaborators must be analyzed and considered as early as possible [11], [13]. They demand particularly an efficient and effective search function and a clear structured system. Therefore we need effective indexing and different start assistances (for new collaborators, department oriented, management oriented, topics referred, based on the standard and others). Apart of the self-driven learning approach, the system must also offer guided learning for new collaborators or for collaborators with little IT competences.

After the appropriate editing the system documentation can be published on the organizational knowledge and learning system. The upload of the content should be user-friendly and simply, because it is normally an activity done by the system manager (responsible for implementing and supporting the management system), which has information security, organizational, managerial and controlling competences and competences in developing management systems and must not be an didactic expert. The constructivist approach in learning requires the possibility of linking concepts and objects following one's own needs. This feature must be available also for graphical objects and different document and media formats, which are widely used in hypertext contents.

To promotes the acceptance of the system the collaborators must be trained on the handling the system and acquire also the necessary media competence [11]. Subsequently, questions will be answered by means of the discussion forum, the help desk and personal partners, e.g. the knowledge and/or system manager. Using the constructivist organizational learning and knowledge system every collaborator can introduce his/her suggestions, ideas or questions directly in a context-sensitive way by referencing all the possible objects of the system documentation. Thus, ambiguous formulations in the documentation are showed up and the system documentation becomes the basis for the continuously optimization of the organization and information security. Thereby we integrate also optimal process modeling, process standardization and transparency with need and objective oriented flexible process and security implementation.

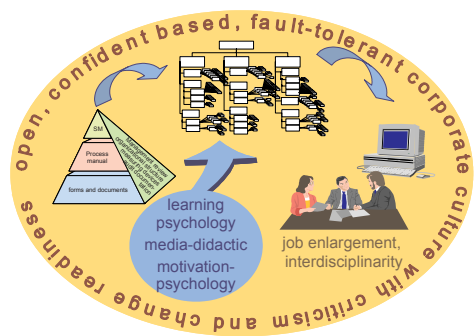


Fig. 2. Integrating need oriented workplace process integrated learning and information security

mmeybodi@aut.ac.ir

The collaborators have sometimes problems to distinguish between problem and optimization, or they do not know to which section of the system documentation they should relate their suggestion or question. Therefore we have integrated the organizational knowledge and learning system with the existing workflow driven problem reporting system (help desk system).

Following the management system requirements also clearly structured processes for the introduction of new collaborators, for the maintenance of the system documentation and for the management of questions, optimizations and problems must to be established, documented, implemented and maintained.

A Requirements for an organizational learning and knowledge system

Based on our project experiences an organizational learning and knowledge system for standard based management systems demands, in addition to the general requirements of IT systems, the following particular characteristics:

- It must be simple and intuitive to handle, it must provide the possibility to use different views of (or leading to) the same object, different start facilities, comfortable search functions, filtering of content using object types, simple uploads of content and links to external literature and it must promotes individual learning and organization by allowing personal bookmarks, annotations, summaries and notes, as well as glossary, FAQs, etc.. [13], [14], [15].
- It must offer secure context-sensitive communication to all elements (discussion forum, chat), as well as newsgroups, wiki, newsletters and whiteboards, support the knowledge distribution, the collective knowledge generation and collective learning [14], [16].
- Uploading and the administration of new content must be simple, with as large didactical and media pedagogic support as possible [2]. There must be the possibility to insert, annotate and discuss context sensitive the content of most different document and media formats (as text, graphic, table, picture, sound records, video). Also creativity tools should be integrated.
- Due to the requirements of the standards for management systems, we need the administration of access rights [17], the support of change processes, versioning with change history and the efficiently and traceable distribution / communication of new or changed content. Depending on the organization culture also testing and examination tools for the traceable learning must be integrated.
- The ideas of the collaborators, their discussion contributions and problem reporting must be implemented in accordance with the established systematic and structured process following the standard requirements and their effectiveness must be evaluated.
- Open interfaces must be available for fostering optimal connectivity with other systems in order to support process integration and simplify the administration [15], [17]. Within the controlling process all measured values should be evaluated by the responsible departments and consequently changes and optimizations should be implemented using the organizational learning and knowledge system.
- The web-based accessibility of the organizational learning and knowledge system supports mobile and working hour's independent learning and teleworking, making also easier the integration of absent collaborators [18].

B Success factors for an organizational learning and knowledge system

Corporate culture processes and IT technologies must be integrated optimally according to the objectives of the organization, to the collaborators needs and requirements and considering media-pedagogical and didactical principles, in order to successfully introduce an organizational learning and knowledge system into management systems. The system is thereby only a tool, which supports the optimization of the organization so far as this is admitted by the culture. Therefore we need an open, confident based, fault-tolerant corporate and learning culture with criticism and change readiness. The collaborators should be interested in new knowledge, able for self-driven learning, have personal employment, team ability and change willingness apart from necessary IT-competences. All managers must use constantly and actively the system and motivate their collaborators in following these principles, promoting in this way learning and new knowledge generation. A strengthening point for achieving this is maintaining an optimal communication internally as well as with external partners.

By introducing this information security manager, system manager and/or knowledge manager extend their own job, needing also the acquisition of the necessary media-pedagogical and didactical knowledge for preparing the content and the necessary skills for supporting e-learning.

Sufficient IT-infrastructure and IT-support are also very important for the project success. Only by using an organizational learning and knowledge system, which meets as far as possible the stated requirements [IV A] and by promoting a workplace need-oriented process integrated learning, a continuously optimization of the organization, in accordance with its objectives, and a sustainable organization success are secured.

mmeybodi@aut.ac.ir

V. Project Experience and Results

The concepts expressed so far have been implemented successfully in several organizations with only information security management systems or also interdisciplinary, holistic, integrated management systems.

The interdisciplinarity was a great challenge and also the great chance. The wide information security knowledge, knowledge about organization theory, management methods and standards were required for the preparing and structuring the content, information-technical knowledge were needed for extending the learning platform to meet the requirements of an organizational learning and knowledge system; didactical, media-pedagogical and communication science knowledge were required for editing the contents.

A Achieving the project objectives

The described concept has been implemented in medium-size service organizations. Most of the organization's collaborators own good media competences and use frequently e-tools.
Nevertheless the platform used in the case studies fulfills only some of the system requirements to an organizational learning and knowledge system [IV A], the adoption of the organization adapted system documentation according to media-pedagogical and didactical principles and taking into consideration a confident based fault-tolerant corporate culture, leads the following case study results collected by measuring the system accesses / user contributions and interviewing the leadership and collaborators:

- Workplace integrated, need-oriented access: the accesses to the system documentation are increased monthly at averaged two accesses per collaborator.
- Improvement of information security: we receive five times more suggestions and ideas, which improves the organization and there information security.
- Employee involvement and knowledge sharing: the communicated ideas, problems and suggestions are discussed and read on the average by a quarter of the collaborators. Thus, the advantages and disadvantages of ideas are discussed and examined by all departments before their possible implementation and they are substantially more balanced and more considered for implementation. Thereby also the collaborator awareness is constantly promoted.
- Practice oriented documentation: while conventional system documentation is usually adapted only once a year, now unclear formulations or missing regulations are soon analyzed and immediately changed according to established processes and automatically communicated to all. Thus, the documentation is adapted optimally to the changing requirements of the organization or laws.
- Shorter initial training periods for new collaborators: new collaborators are quickly introduced into the system at their first working day and afterwards they learn in a self-driven need oriented way, all relevant contents for their specific work. Thus the documentation is always accessible the new collaborator can focus on the principle information and can after need-oriented access to all necessary regulations and process to fulfill his job. Thereby the lead time could be abbreviated around a quarter. New collaborators identify themselves substantially earlier with the corporate culture, they feel themselves also more integrated into the organization, can execute their tasks faster well, whereby the productivity increase and possible errors are avoided.

The manager of an organization with an organizational knowledge and learning system is particularly enthusiastic for the sustainable promotion of an open, confident based, fault-tolerant corporate and learning culture with criticism and change readiness.

Standard based, holistic management systems are by there clear structured, holistic, systemic approach, there strong orientation to interested parties, there systematic process approach and the continually optimization through measurement and facts an excellent reference models for a holistic introduction and implementation of information security and data protection.

Using an organizational learning and knowledge system apart from the system documentation, we can offer with less accessory cost due to the existing also other relevant information, e.g. transport information, information about hotels and restaurant and also trainings based on Blended Learning for the human resources development.

Based on the experiences in different case studies the application of this integrated organizational learning and knowledge concept is recommended for medium and large sized organizations and enterprises with an confidence-based, open, innovative and fault-tolerant corporate and learning culture, where all collaborators command sufficient it competences, particularly in know-how enterprises, distributed locations, many collaborators in field service or with flexible working-time model.

B Cost and Benefits

This new interdisciplinary holistic organizational learning and knowledge concept requires in comparison to previously applied introduction of a standard-based holistic interdisciplinary the organization adapted system additionally the restructuring of the system documentation in accordance to media-pedagogical and didactical principles, an organizational learning and knowledge system and the implementation of the documentation on it. The restructuring required in the case studies a slightly higher effort (approximately 1-2% of the total effort).

mmeybodi@aut.ac.ir

Opposite to the costs are the large competition advantages through need-oriented process integrated learning to improve the organization and there information security by means of collaborators ideas, suggestions and discussion contributions. These advantages can be measured on one hand by the reached objectives of the project [5.1]. The influence to the sustainable achievement of the organizations objectives must be weighted essentially more strongly. In the sense of a holistic, systemic management the different strategies and there measurements influences each other and all individual actions together determine the achievement of the organizational objectives and the organizational success, which is at the end the essential critical factor. These effects must be evaluated in a longer term and could be objective of a subsequent study.

VI. OUTLOOK

Learning or knowledge management systems must be extended [IV A] to organizational knowledge and learning systems for need-oriented, workplace process integrated learning.

By introducing an organizational knowledge and learning systems for standard based management systems with integrated information security all success factors should be considered [IV B].

The training of information security manager should consider more:

- the principles for didactical and media-pedagogical restructure of system documentation,
- knowledge management requirements and
- the principles of holistic, interdisciplinary, standard based management systems.

The standards for management systems should underline more and promote the importance of an open, confident based, fault-tolerant corporate and learning culture, knowledge management and integrated learning.

VII. CONCLUSION

Integrating information security management and other standard based management systems, adopting it to organization needs, restructuring the system documentation in accordance to media-pedagogical and didactical principles and implementing it on a constructivist organizational learning and knowledge system with an open, confident based, fault-tolerant corporate and learning culture promotes workplace integrated, need-oriented access, improvement of information security, employee involvement and knowledge sharing, practice-oriented system documentation, shorter initial training periods for new collaborators and thereby a continuous optimization of information security and the organization. Thus by fostering workplace need-oriented process integrated learning and improved information security the sustainable success becomes guaranteed.

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mmeybodi@aut.ac.ir

E-DETECT – Virtual Platform for Education in Computed Tomography

Marius BULGARU Marius.Bulgaru@tcm.utcluj.ro
Sorin BILEGAN Sorin.Bilegan@tcm.utcluj.ro
Laura GRINDEI Laura.Grindei@et.utcluj.ro

Abstract: **E-DETECT package, created for dissemination through learning concerning the computed tomography knowledge, brings many indirect benefits. E-DETECT is useful in the training and service activities carried out by the companies that produce industrial tomographs or use them for applications, because it gives the customer the possibility to witness the power of the new technology. The virtual platform offers acces at an on-line course – Demo-DETECT and a virtual computed tomography – Virtual-DETECT. Structured in two competence levels it allows an easy understanding of the physical phenomena which takes place and the component's operation. The virtual reality tomograph developed offers the user a 'hands on' experience for the main applications of this technology in the industry. The connection between theory and practice realized in the educational package leads to the growth of the user's knowledge level as well as to the confidence attainment in the possibility to meet the new technologies.**

1. Introduction

In a knowledge-based and customer-driven economy, it becomes increasingly important to integrate high-technology into complex goods and services which are directed towards individual user requirements. In the future, the competitiveness depends on how fast and how flexible new products can be launched onto the market.

Therefore, new, efficient, user and eco-friendly product design and engineering technologies are urgently required. The new approach is to base the necessary virtual models on volumetric Computed Tomography (3D-CT) data. The availability of 3D-CT data at different steps of the product development process allows not only high quality surface modeling or geometrical inspection but also the analysis of flaws, material inhomogeneity or material structures and helps to optimize the manufacturing parameters especially for new materials.

The main project objectives of DETECT was to develop new basic hardware components and algorithms for fast and accurate 3D-CT scanning for parts of any complexity and large dimensions, new algorithms for automated CT image processing, fast surface and solid modeling as well as methodologies for the integration of the new technologies into the rapid product development and manufacturing process. A next generation CT prototype will be set up for validation and testing. A particular attention will also be given to make these new technologies known to the European key industries.

2. E-Detect

Dissemination of research projects using articles in magazines, science papers at conferences, presentations at fairs and exhibitions, etc. is done especially for experts in the field. This has the disadvantage of a small impact.

In the DETECT project - "New product Design and Engineering Technologies based on the next generation Computed Tomography", financed by the EU community in the PC6 program, the "dissemination by learning" concept has been applied, which has a big impact being receipted by specialists as well as potential users of the CT technology.

The theoretical knowledge was materialised in an e-learning package, E-DETECT, composed of two modules:

- Demo-DETECT, which holds the theoretical knowledge about the CT technology;
- Virtual-DETCT, a virtual reality software that offers the user a 'hands on' experience on a computed tomograph.

Both modules are available on-line at the address: www.detect-eu.com .

2.1 Demo-Detect

The design and implementation of Demo DETECT was focused on the creation of an on-line course providing a tutorial overview on industry applications of computed tomography.

The site was implemented using Macromedia Dreamweaver MX and the PHP and JavaScript programming languages, respectively.

The site design includes a banner that consists of a logo and the title of the course, a menu with several options like the selection of the desired module, the download of the Virtual CT software, links to the DETECT project, contact details, glossary of terms and other links to and the main frame.

The graphical interface (Fig.1) for the new on-line course was created using menus implemented in PHP and JavaScript, several web pages being realized for glossary of terms, contact information, etc.

The on-line course design and development consisted of several stages:

- analysis of the characteristics, technologies and design

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 315–320.
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mmeybodi@aut.ac.ir

methods of the teaching materials for on-line courses usually distributed within e-learning platforms;

- comparative analysis of the commercial tools designed for creating on-line content: course authoring tools, web authoring tools, multimedia editors and technologies, virtual worlds, etc.;
- study of multimedia technologies, content conversion tools, and web programming tools for interactive web pages creation;
- design and development of the on-line course: the course was divided in modules, for each module multimedia teaching materials were designed and developed as tutorials together with the glossary of terms, using PHP and JavaScript programming languages.

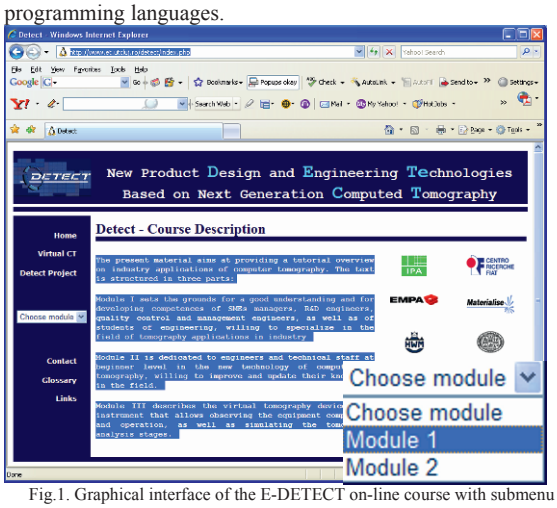


Fig.1. Graphical interface of the E-DETECT on-line course with submenu for selecting the modules

The menu was designed to improve the navigation through the web site and was positioned in the left side of the frame, being included in all the web pages that were created for this on-line course . The main objective for the implementation of this menu was to efficiently switch between the pages of the web site. Therefore all the pages created included the following PHP command at the beginning of the document. This command automatically includes the header file (upper banner and menu):

```
<? include('header.php'); ?>
```

The menu was realized using PHP and JavaScript programming languages. An example of the code used for selecting the course modules is presented below:

```
<SCRIPT language="JavaScript">
<!–start hide
function home(
{
parent.location.href='index.php'
}
function selectedItem (form)
{
if form.URL[1].selected)
Count=parent.location.href="module1.htm";
if(form.URL[2].selected)
Count=parent.location.href="module2.htm";
}
// end of hide→
</SCRIPT>
```

The modules selection is made using a form as it is ilustrated below:

```
<form name=CHANGE-URL>
<p align="right">
<select name=URL size=1 class="style48"
onChange=selectedItem(this.form)>
<option selected>Choose module </option>
<option>Module 1 </option>
<option>Module 2 </option><font
face=Arial,Helvetica><font color=#006699><font size=-1>
</FONT>
</select>
```

The information is structured in three parts:

- **Module 1,** sets the grounds for a good understanding and for developing competences of SMEs managers, R&D engineers, quality control and management engineers, as well as for students of engineering, willing to specialize in the field of tomography applications in industry.

The content of Module 1 is:

1. Objective
   - 1.1. Introduction
   - 1.2. Radiography versus Tomography
2. Components of an industrial tomography device
   - 2.1. X-Ray Source
   - 2.2. Detectors
   - 2.3. Fan beam CT
   - 2.4. Cone beam CT
   - 2.5. Manipulator System
   - 2.6. Data acquisition system – the point cloud
3. Applications
   - 3.1 Applications in industry – non-destructive control
   - 3.2 Applications in industry – products design
     - 3.2.1 Reverse engineering
     - 3.2.2 Rapid prototyping
     - 3.2.3 Measuring
     - 3.2.4 First article inspection
   - 3.3 Applications - research

Module 1 and 2 on-line tutorials were created in PowerPoint and converted to HTML format and include

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movies, (Fig.2), and animations, (Fig.3), that can be played on the user's mouse click.

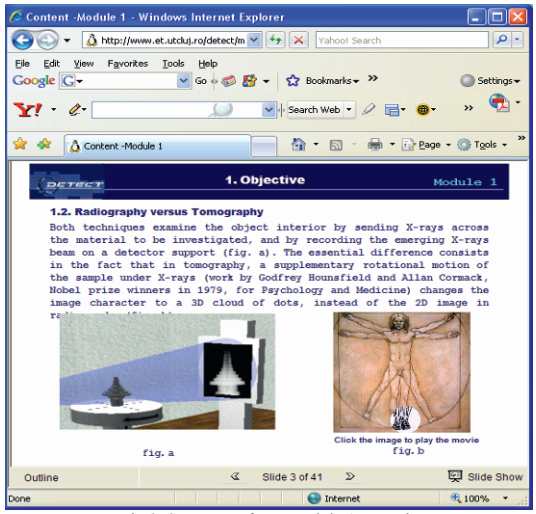


Fig.2. Sequences from Module 1 – movies

- **Module 2,** (Fig. 4, 5) is dedicated to engineers and technical staff at beginner level in the new technology of computed tomography, willing to improve and update their knowledge in the field.

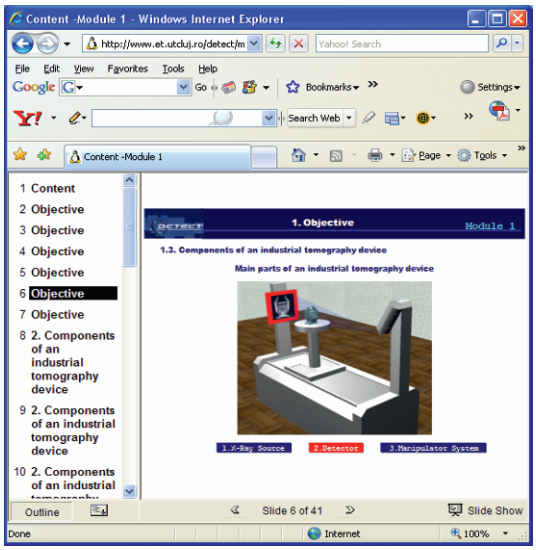


Fig. 3. Sequences from Module 1 – animated buttons

The content of Module 2 is:

1. History
2. X-Ray
2.1. X-Ray sources
    2.1.1 X-Ray tubes
    2.1.2 Linear accelerator
    2.1.3 Synchrotrons
2.2. Macrofocus, minifocus, microfocus
3. Interaction of the radiation with matter
4. Detectors for X-Ray
5. Converter system
6. Digital Processing for CT
    6.1 Digital imaging for X-Ray
    6.2 Image processing techniques
7. The Modulation Transfer Function (MTF)
8. Image quality indicators

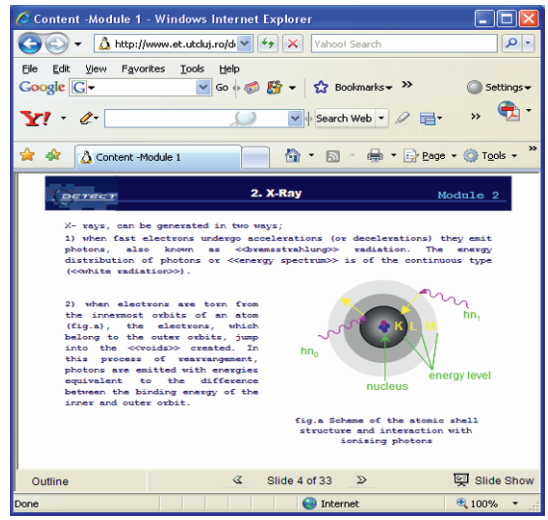


Fig. 4. Sequences from Module 2 tutorial

The glossary of terms includes scientific terms in alphabetical order, very useful for a better comprehension of the knowledge taught within this on-line course. In Fig.5 several terms are illustrated with their significance. In this glossary graphical images and also movies, sounds or animated sequences can be included.

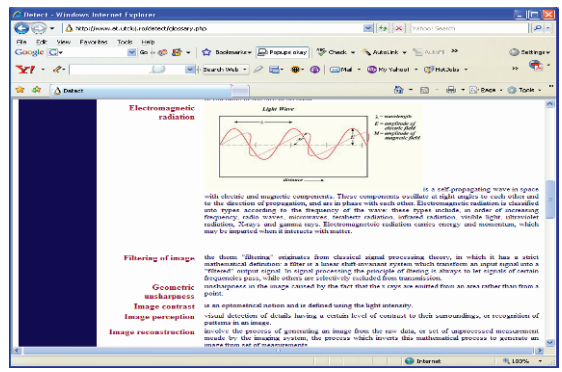


Fig. 5. Sequences from Glossary of terms

mmeybodi@aut.ac.ir



Fig. 6. The Virtual DETECT interface

2.2 VIRTUAL-DETECT

The virtual CT was designed in such a way that it presents:

a) the main components of a Computed Tomograph (chassis, sensor, detector, manipulator and actuation devices);

b) the functioning principle;

c) the simulation of data acquisition and processing of the point cloud, and the presentation of a case study.

The main components have been designed in SolidWorks and ProEngineer and then exported and assembled into the virtual environment (Quest 3D).

The development of the virtual instrument has been materialized by taking the following steps (Fig. 7):

1. Planning

In this first stage it has been settled to which objectives the application has to respond, meaning:

1. visualization of a virtual CT and it's components
2. the possibility to maneuver the CT using the keyboard or the virtual interface

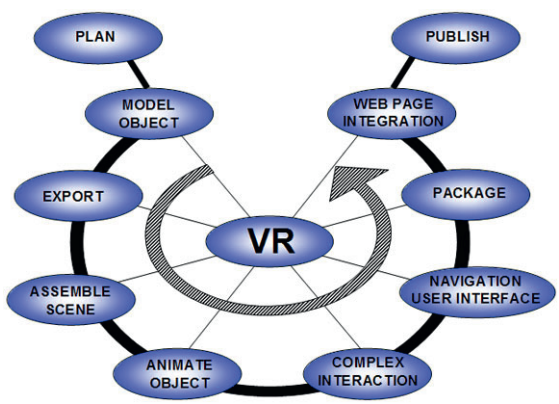


Fig. 7. The steps needed to develop the VR application

3. the possibility to visualize the data acquisition technology
4. the possibility to simulate and interact with the virtual CT for various workpieces and work parameters.

2. Object modelling

In this stage SolidWorks was used to model the main components of the virtual tomograph: the frame, the X-Ray tube, the detector, the positioning system and the screens used to visualize the data. The 3D objects have been exported in a compatible format to facilitate their import in the VR environment. The following image (Fig. 8) shows the CT's frame in SolidWorks.

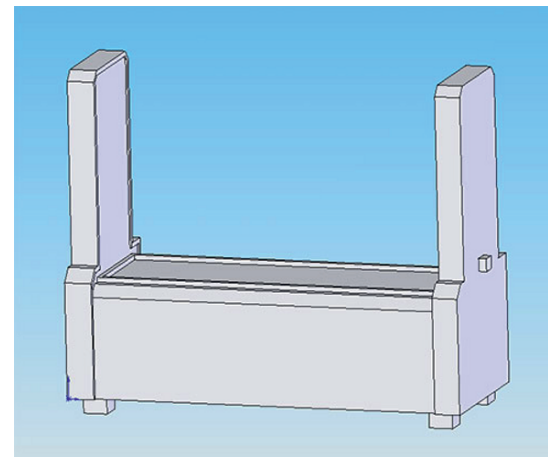


Fig. 8. The CT's frame in SW

3. Scene assembly

Fig. 9 illustrates the way the components are assembled in the virtual reality. The parts are interconnected through constraints between their geometry and by mathematical relations.

4. Animating the objects

The objects in the virtual reality are animated by dynamically changing their coordinates along the three perpendicular axes (X, Y, Z) and they are rotated by changing their heading, pitch and bank angle in relation to the world's coordinate system.

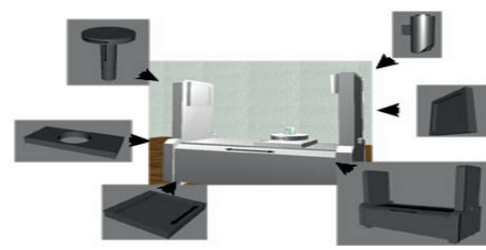


Fig. 9. Assembly of the 3D components

mmeybodi@aut.ac.ir

Fig. 10. shows one particular object's movement programming in the virtual reality environment (in this environment the Z axis is the depth axis). While the X and Z axes are dependent on other components positions, the Y axis is controlled by the user, by pressing the UP or DOWN keys or two other buttons on the virtual interface.

Its rotation is also controlled by continually changing the object's heading angle when needed.

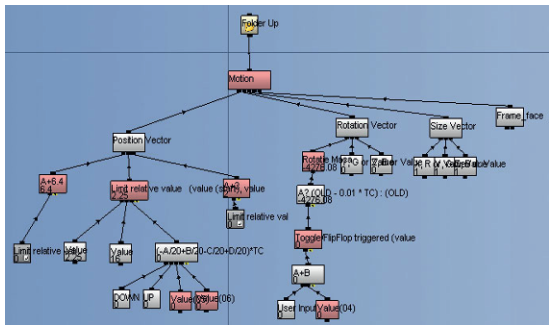


Fig. 10. The animation of an object

5. Complex interaction

At this stage the tomography process has been simulated. The X-Ray tube shoots out a bundle of rays that penetrate the workpiece, (Fig.11). The interaction between the X-Ray's cone and the workpiece is visualized in one of the screens. The positioning system can be operated so that the cone fully covers the workpiece or just a part of it.

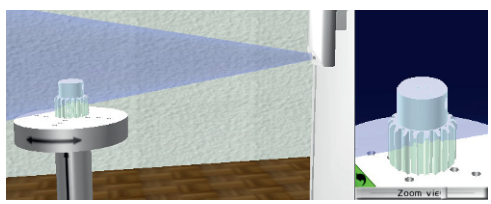


Fig. 11. The tomography process

6. Navigation, manipulation, user interface

The virtual CT can be visualized from any angle. The rotation around it is activated by pressing and holding the middle mouse button while moving it at the same time.

A window was created in this stage which frames the actuation system, divided in three parts: "*Position*", "*Settings*" and "*Control*", (Fig.12).

In the "*Position*" section the buttons for the control of the components' position on the three translation axes and one rotation axis are located. In the same section the components' position on the three axes is numerically displayed.

In the "*Settings"* section the values for the intensity and voltage of the X-Ray can be modified, resulting an X-Ray with a penetration power stronger or weaker, depending on the application and on the material from which the piece is made of.

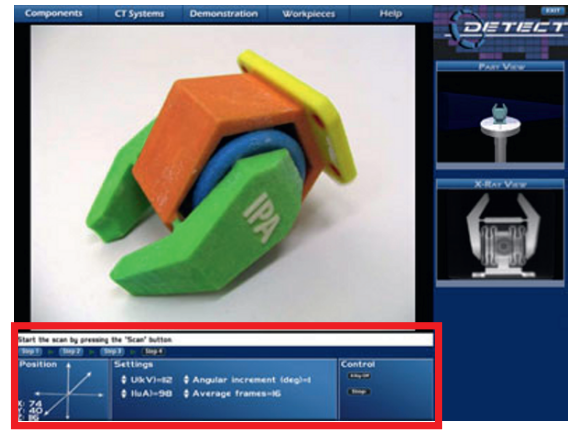


Fig.12. The user interface

In the "*Control*" section two buttons can be found, one for the starting and stopping of the X-Rays and the other one for starting and stopping the scan. The latter is available only when all the conditions for the start of the scan are met (the right application and workpiece, the optimum position for scanning and the correct intensity settings of the X-Ray).

"*CT Systems*" allows the switch between the two types of X-Ray beams (cone and fan) to emphasize the differences between the last generation of tomographs and the previous one.

2.3 Applications

Virtual-DETECT allows the selection of the different applications in industrial tomography simulated by the virtual CT.

The main applications (Fig.13) are:

a. Inspection
b. Non-Destructive Testing
c. Measuring
d. Reverse Engineering
e. Nominal to Actual Comparison
f. Rapid Prototyping

3. Conclusion

E-DETECT is an educational package that can be used by:

- industrial users of the tomography technology
- potential clients who wish to buy an industrial tomograph
- students that wish to specialize in the tomography field
- professors and trainers.

The exploitation of the educational package is made by:

- understanding and achieving of theoretical knowledge regarding the tomography technology
- knowing the working principles and components of an industrial tomograph

mmeybodi@aut.ac.ir



Fig. 13. Applications of industrial tomography demonstrated with VIRTUAL-DETECT

- obtaining abilities for manipulating an industrial tomograph
- understanding the large field of applications and comparing them with other existing solutions at the present moment.

The expected results are indirect and refer to:

- understanding the advantages of using new technologies that lead to an increased quality for the products and the obtaining of profit by reducing the time needed for their development
- the increased qualification of the personnel that uses computed tomographs
- improving the level of occupationally training of university graduates.

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mmeybodi@aut.ac.ir

Formative Assessment and E-Portfolios Depository or Expository?

Magnus M.B. Ross and Mary P. Welsh
Faculty of Education
University of Strathclyde
Glasgow G13 1PP
Scotland

Abstract - The action research project discussed in this paper was implemented in an Educational Studies Module during the first year of a 4-year degree course leading to the award of a BEd (Honours) Degree. The aim of students on the course is to become primary school teachers in Scotland. The course enrols over 160 students per year, and was identified in feedback as being a "difficult" class. Tutors witnessed a lack of engagement with course content and a resultant disappointing quality of student work. There was a perception of mismatch between requirements for final summative assessment and work expected from students during the module. These considerations resulted in a complete re-structuring of the existing instructional design, underpinned by the introduction of a system of peer-based formative assessment and innovative use of a proprietary e-portfolio system.

CHANGING CONTEXTS OF HIGHER EDUCATION AND INSTRUCTIONAL DESIGN

In recent years, governments worldwide have sought to increase participation in higher education. Faced with an increasingly diverse student population, higher education institutions have adopted new approaches to teaching, learning and assessment and have monitored the implementation of different strategies through rigorous research.

One common concern has been the extent to which students actively engage in learning. Marton and Saljo's (1976 a, b) seminal research identified two approaches adopted by students – deep and surface learning. The characteristics they identified were echoed in research carried out in the UK, Entwistle and Ramsden, (1983) and in Australia, Biggs (2003). Biggs' model of 'constructive alignment' was adopted as one element of the re-design of the module under discussion.

Another concern has been the extent to which current assessment practices are effective. Governments seek to create reflective, self-regulated learners who engage in a process of lifelong, deep learning and seek also to develop assessment instruments capable of monitoring progress effectively. Increasing evidence from literature (Boud, 1995; Black & Wiliam, 1998; Brew, 1999; Falchikov, 2001; Gibbs & Simpson, 2004; Nicol & Milligan, 2006; Nicol, 2007) supports the introduction of formative assessment methods. In Scotland, research into the introduction of formative assessment in higher education has come under the umbrella of the Re-Engineering Assessment Practices in Higher Education (REAP) Project. REAP is financed by the Scottish Higher Education Funding Council and provided funding for the action research project reported here.

Three main research questions were posed:

- How can we change the assessment system to improve the learning experience of students?
- How can we modify the leaning environment?
- How can we offer timely, high-quality feedback to support student learning and achievement

Approaches to learning by students participating in the module discussed in this paper, were similar to those identified by researchers highlighted above. Experience in the module suggested that students generally had a fairly passive view of the learning process and expected that tutors could somehow provide them with all the understandings needed for a successful outcome. The main strategy introduced enabled students to take greater responsibility for their own learning – a notoriously difficult concept to establish, particularly, in first year undergraduate study.

ELEMENTS OF THE INTERVENTION

Prior to the introduction of the revised course design, students followed a year-long instructional programme comprising 20 lectures, followed by ** tutor-lead tutorials. Students were required also to maintain an individual paper-based portfolio detailing their understanding of the various study topics. This portfolio was submitted for evaluation to course tutors at a mid-point in the module programme. Portfolios produced were of widely varying quality and the entire evaluation process was largely arbitrary, with no real attempt made to standardize tutor responses. Students who seemed to be making unsatisfactory

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 321–325.
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mmeybodi@aut.ac.ir

progress were offered limited remediation strategies. Not only was the process inefficient in meeting the learning needs of some students, it was also inefficient in terms of use of staff time.

The revised instructional design incorporated the following:

- A series of 'Learning Milestones', occurring at natural breaks in the lecture programme, were identified. These 'Learning Milestones' were Core Tasks constructed to permit students to work individually and collaboratively to formulate responses to a Core Task associated with the particular topic that had just been studied in lectures and tutorials.
- The Core Tasks allowed an incremental increase in the demands placed on students and helped students develop critical skills through consideration of differing theoretical perspectives on learners and learning presented.
- A self and peer assessment methodology, supported by tutor mediation, was adopted as the basis for formative assessment associated with each 'Learning Milestone'.
- A proprietary e-portfolio system, 'PebblePad', was adopted as the medium for the formative assessment strategy. As this was already available in other parts of the course, its adoption also presented an ideal opportunity for students to make links more easily between different modules.
- To maximise effectiveness of formative tutor feedback, this was provided to only one sub-group in a tutor's class following each Core Task submission. Students were then required to participate in further peer analysis and interpretation of both the submission selected and its tutor feedback. This encouraged development of professional reflective skills.

In researching the theoretical framework for the intervention, the team considered the work of many other researchers in the field. However it was the work of a researcher from their own institution, David Nicol, (Nicol & Macfarlane-Dick, (2006); Nicol & Milligan, (2006)), that provided a viable foundation. Initially, the framework adopted was based on that outlined in Nicol & Milligan (2006), however, as the project drew to a close, a paper, delivered by Nicol at a REAP International Online Conference, in May 2007, offered an improved solution to the problem. It is this latter framework that is discussed here.

Nicol (2007) detailed ten principles of good assessment and feedback, analysed over two dimensions:

"Good assessment and feedback principles should:

1. Help clarify what good performance is (goals, criteria, standards).
2. Encourage 'time and effort' on challenging learning tasks.
3. Deliver high quality feedback information that helps learners self-correct.
4. Encourage positive motivational beliefs and self-esteem.
5. Encourage interaction and dialogue around learning (peer and teacher-student).
6. Facilitate the development of self-assessment and reflection in learning.
7. Give learners choice in assessment – content and processes.
8. Involve students in decision-making about assessment policy and practice.
9. Support the development of learning communities.
10. Help teachers adapt teaching to student needs."
(Nicol, 2007, p. 3).

An examination of principles 1, 3, and 9 form the basis of the remainder of this paper.

Helps clarify what good performance is

For students to be able to achieve learning goals it is essential that they understand these goals and feel they are able to make progress towards achieving them (Sadler, 1989; Black & Wiliam, 1998). As observed in course evaluations, research by Hounsell (1997), and Sadler (1989), showed that there is often a mismatch between students' and staff" understandings of goals, and of assessment criteria and standards. To overcome this difficulty, Orsmond et al. (1996) recommend that students be given 'exemplars' of successful performance. Limited time in this initial intervention led to another recognised approach being adopted with an experienced member of the course team devising a criteria sheet offering carefully crafted performance-level indicators to scaffold the process. This provided students with a simple, effective guide to evaluating

Deliver high quality feedback information that helps learners self-correct.

Some researchers have questioned the ability of students to offer good quality feedback to peers, however Boud (2000, p. 158) argued that the most effective way of making students "close the loop" (Sadler, 1989, p. 121) in the 'task-performance-feedback' cycle is by allowing students to re-submit work *after* feedback has been offered *before* moving on to the next task. Nicol and MacFarlane-Dick (2006), highlight the importance of offering good quality, timely feedback, based on self-regulation:

> ' … [It] is information that helps students trouble-shoot their own performance and self-correct, that is, it helps the students take action to reduce the discrepancy between their intentions and the resulting effects … '(Nicol and Macfarlane-Dick, 2006, p. 208).

mmeybodi@aut.ac.ir

In this project, students valued the feedback offered by peers and, through submission of a group synthesis response, were given the opportunity to re-submit, albeit in an altered form. Through engagement in a common task, students were able to identify areas of difficulty for peers and were able to offer supplementary, often contrasting, views of the issue. Feedback was offered quickly and descriptively in a process, similar to the dialogic process advocated by Lunsford, (1997).

Support the development of learning communities

Novice practitioners need a medium in which knowledge and understanding may be developed without fear of ridicule or criticism. This can be difficult to create. However, the research project discussed here has demonstrated that effective use of electronic learning environments (ELEs), such as e-portfolios, supported by use of blended learning strategies, in this case the development peer and self-assessment skills, leads to the creation of practitioners who are truly reflective from the very beginning of their professional careers. It is not only technological skills that are developed - appropriate critical thinking skills and an understanding of what it means to be information literate, are also developed. This combination supports engagement in, and enrichment of, the educational experience. Significant savings in staff time, both in the seminar programme and in time devoted to assessment activities were achieved. There has also been improvement in quality of student written work and in examination results.

The specific trigger for this intervention was recognition that the e-portfolio system, 'PebblePad', used elsewhere in the undergraduate programme had potential to be used in a totally different way. Previous research has concentrated on the use of e-portfolios mainly as a repository for materials. The intervention was innovative in its use of the e-portfolio as a vehicle to facilitate self and peer-based formative assessment processes.

There was no suggestion that the development would lead to a predominantly e-learning approach or that traditional approaches to lectures or tutor led seminars would be abandoned. It is clear however that the new blend of methodologies has had a feedback effect leading to subtle, and sometimes significant, changes in normal operational practice across the whole range of learning experiences.

RESEARCH METHODOLOGY

The merits of the design adopted, action research, as a method of promoting change in educational settings have long been recognised. Recent researchers Robson (2002), McNiff and Whitehead (2006) and Somekh (2006) have continued in this vein and many of the best known action researchers in education have been practitioners in that context, or have been professional researchers supporting practitioners who wish to initiate change in the setting in which they work.

DATA COLLECTION AND ANALYSIS

A mixed-method approach to data collection allowed both quantitative and qualitative data to be collected and subsequently analysed. Previously, evaluation of the module was carried out using a questionnaire, issued to all students, following the final summative exam. At the end of the second semester this year, three weeks before the final summative exam, the process was repeated. A modified version of the previous questionnaire was used in order that some comparisons might be made between results. Data from this questionnaire was subjected to descriptive statistical analysis using SPSS.

A REAP evaluation team administered a second questionnaire on the same occasion. This was developed and analysed independently by the evaluators who also conducted focus group meetings, one for students, and one for staff.

FINDINGS AND CONCLUSIONS

Findings from focus groups and questionnaires have shown that, overall, the students were positive about this learning experience with the majority of students agreeing that it was possible to relate the module to the course and that it provided good insight to the subject. Peer feedback was greatly valued [Table 1]

Nevertheless, there are significant anomalies. 72.2% reported that collaborative working enhanced their learning, however, in spite of 67.5 % of respondents finding peer feedback helpful, only 50.9% found group feedback, offered by tutors, relevant to their own work! This would seem to imply that the students themselves have assumed the role of tutors for each other and are perceived as effective in that role by peers.

Open responses in the questionnaire indicate that peer based formative assessment has been effective in developing effective learning communities. Typical comments were:

> 'I liked working in groups for the core tasks. It helped me to understand things better when the group discussed it and bounced ideas off each other.'
>
> 'The group work really helped me further my development and development of the content.'

However there are still some challenges. 52.7% of respondents either 'Strongly Agreed' or 'Agreed' that use of the e-portfolio environment to support the blended learning approach made an impact on their ability to engage in the course at a distance, but only 23.5% said it helped them organise their course work. Awareness of the wider benefits of blended learning appears still to be lacking and requires further research.

mmeybodi@aut.ac.ir

I found the feedback from peers helpful

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	18	15.7	15.8	15.8
	Agree	59	51.3	51.8	67.5
	Neutral	28	24.3	24.6	92.1
	Disagree	7	6.1	6.1	98.2
	Strongly Disagree	2	1.7	1.8	100.0
	Total	114	99.1	100.0	
Missing	999	1	.9		
Total		115	100.0		

Table 1

The vital factor underpinning the success of this particular blend of methods was the extent to which students and staff engaged in the peer assessment process. To maximize this engagement, learning outcomes for every aspect of the course needed to be made explicit for both staff and students. Furthermore students need guidance in identifying the standards/ criteria that apply to their work and in making evaluations about how their work relates to these standards (Boud, 2000). Experience of staff in making such judgments can provide essential scaffolding for student learning processes. Underpinning principles of social and communal constructivism supported a radical process, with far-reaching implications for change.

It is interesting that, in response to questions in the end of year survey questionnaire, students seemed to prefer peer feedback to that offered by tutors. This could be a measure of the effectiveness of the methodology in developing self-regulating, reflective skills. There are implications for tutor involvement and it can be argued that this outcome is beneficial for a system of higher education where classes are increasingly large and diverse and where tutors face increasing pressures and demands on their time.

It has become obvious that the benefits of the process have far outweighed the difficulties that have had to be overcome. For example, despite student fears about lack of preparation for the final summative exam, the arithmetic mean score for the written section rose from 59% in the academic year 2005-2006 to 70% in the 2006-2007. Peer based formative assessment has been seen to bring about learning, social and professional gains for all involved. The use of blended learning to support the development of reflective, self-regulated classroom practitioners, skilled in formative assessment strategies and the pedagogy of effective e-portfolio use require further research and development.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

A Web Service-based Solution for E-Learning Resources Annotation and Retrieval – Conceptual Architecture

Mihaela Brut[1], Sabin Buraga[2]

Abstract—**The article proposes a Service Oriented Architecture (SOA) solution for e-learning materials semantic annotation purpose. The proposed services extend the current e-learning standards facilities of associating metadata to Learning Objects by expressing each metadata in the most appropriate metadata standard format, and also by using the suitable high-level ontologies and domain ontologies in order to annotate the concepts inside the Learning Objects.**

I. Introduction

The e-learning field domain encountered a remarkable development in the last years, especially due to the availability and accessibility of many support application types.

There exist three architecture types for the actual e-learning platforms: client-server, peer-to-peer, and Web services-based architecture.

A major advantage of the Web services based architecture consists of the possibility of accessing the various Web services functionalities not only inside the platform, but also from the other e-learning platforms, with other architectures. Also, the services can form a Web mash-up in order to provide a new functionality and/or a new user-experience.

Our paper purpose is to propose a Service Oriented Architecture (SOA) solution able to structure educational resources in an efficient manner, and providing the possibility to be integrated (invoked) within any e-learning platform. Our approach is motivated by the weak support for the Semantic Web Technologies provided by the actual Learning Management Systems (LMS). These should take advantages of semantic services, interoperability, ontologies or semantic annotation.

Our idea is to design certain Web services in charge with annotation and retrieval facilities which will extend those provided by the actual LMS. Also, our proposal makes use of the Semantic Web techniques for modeling resources, processes and services.

The main focus will be on designing Web services for associating metadata to the Learning Objects, considered as a whole or to their component resources.

The paper is organized as follows: section 2 will give an overview regarding SOA and Web services and section 3 will present our proposal regarding a SOA-based structure of an e-learning platform. In section 4 will discuss the set of possible functionalities provided by an annotation service able to manage multiple metadata standards and different types of educational content.

1.Mihaela Brut, Faculty of Computer Science, Alexandru Ioan Cuza University, 16 Berthelot, Iasi, Romania, (phone: +4-0746-054774; fax: +4-0232-201490; e-mail: mihaela@infoiasi.ro).

2.Sabin Buraga, Faculty of Computer Science, Alexandru Ioan Cuza University, 16 Berthelot, Iasi, Romania, (phone: +4-0232 201544; fax: +4-0232-201490; e-mail: busaco@infoiasi.ro).

II. Web Services Conceptual Model

The term *Service Oriented Architecture* [4] refers to the design of a distributed system. SOA is a novel design methodology and architecture aimed at maximizing the reuse of multiple services (possibly implemented on different platforms and using multiple programming languages).

Reusability is one of the characteristics for a service.

A Web service is an interface that describes a collection of operations that are network accessible through standardized XML messaging [2]. The service implementation is hidden behind its interface and is not relevant for the consumer (for example, a component that needs that functionality provided by the service).

These services, their descriptions and their relationships, along with the principles governing its design and evolution form the SOA architecture.

In a SOA platform, the services generally have some important characteristics [4]:

- Services are individually useful – they are *autonomous*;
- Services must be *loosely coupled*. This expression implies that services discover the needed information at the time they need it. The benefits offered by this characteristic are: flexibility, scalability, ability to be easily replaced, and fault tolerance;
- Services can be composed to provide other services – *composability*. This promotes the reuse of existing functionality;
- Services can participate in a workflow. An operation performed by a service will depend on the messages that are sent or received – service

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 326–331.
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mmeybodi@aut.ac.ir

choreography;

- Services can be easily discovered (*discoverability*), eventually in an automatic manner. For that, services must expose details (and additional meta-data) such as their capabilities, interfaces, policies, supported protocols. Other details such as the programming language or the information about the platform are not useful for consumers and – usually – are not revealed.

The Web services conceptual model [5] is based on the interactions between three entity types (see *Figure 1*):

- *Service Provider* – the platform which host and provide access to the Web service;
- *Service Requestor* – the application which looks for and invokes or initiates an interaction with an Web service;
- *Service Registry* – a searchable registry containing service descriptions, where the service providers could publish their own description and descriptions for their provided services.

These Web services entities could interact among them through three operation types:

- *Publish* – A Service Provider could publish into the Service Registry the descriptions of its services;
- *Find* – A Service Requestor could find some interest Service Descriptions into Service Registry (by querying it);
- *Bind* – The Service Requestor invokes or initiates an interaction with the retrieved service at run-time (by using the binding details provided by the service description in order to locate, contact and invoke the service).

The above mentioned entities and operations act upon three major Web services objects:

- Web service software module;
- Web service description;
- Client application.

The key specifications concerning the Web services are:

- *XML* (*Extensible Markup Language*) – a meta-language that became an ubiquitous paradigm for (semi)structured information interchange;
- *SOAP* (originally known as *Simple Object Access Protocol*) – an XML-based protocol which allows the exchange of structural information (the request and the response of a service) in a distributed and decentralized environment;
- *WSDL* (*Web Services Description Language*) – an XML-based language used to describe a Web service (service attributes, service interface and other properties).

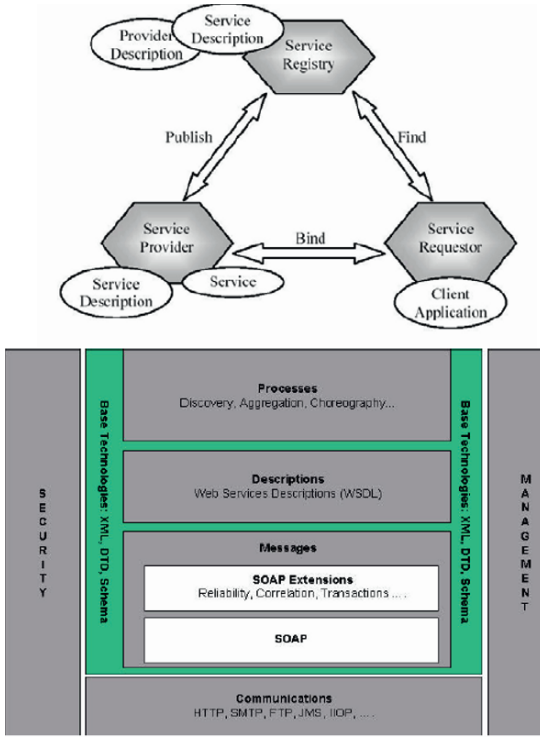


Fig. 1. Web Services Conceptual Model

The two concepts – SOA and Web services – will be used together in our proposal, but they are not mutually dependent. For more details, see [4].

III. The E-Learning Services Oriented Architecture

The complex activities within an e-learning platform – such educational content editing and annotation, student activities supervision, or user administration – could be modeled as processes or workflows, which manipulate objects of student type and learning objects [10]. These could be attributed and associated with various e-learning platforms components. Thus could be used a workflow management system in order to control these activities.

Such vision makes possible a Service Oriented Architecture of the e-learning platform (see the *Figure 2*): the Web services could facilitate the content management, as well as the modeling of other activity types within the e-learning platform – for example, the student assistance during the documentation/learning process [7].

So, the various functionalities of the e-learning system could be de-composed and detached by the platform, in order to be provided as individual autonomous Web services. This decomposition is based on an appropriate modeling of the processes, objects and interactions between these, in the same manner they occur within the platform.

In addition, the results should be re-used, according the

mmeybodi@aut.ac.ir

concrete needs, by the various other services provided by different institutions. The e-learning platform functionalities will result from the appropriate composition of multiple such services.

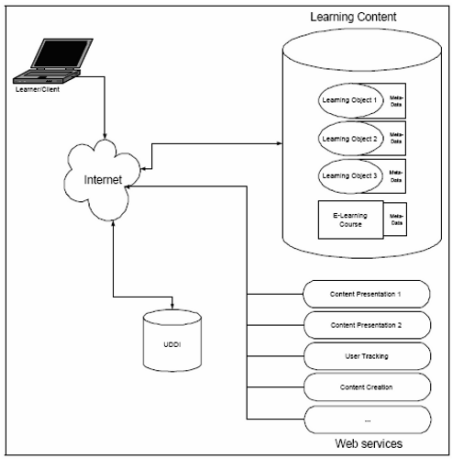


Fig. 2. A Services Oriented approach for the Learning Management Systems

In this architecture, the first step would be registering each service within a registry, so that services can then be invoked through the service broker. The broker is a central component in this distributed architecture: it allows communication between independent service providers and requesters. In particular, it attempts to match a request for a service to the closest service that can provide that functionality. Services interact with resources and, in particular, subscribe to relevant ontologies. Other resources include databases and documents published on the Web [6].

An e-learning portal might include services such as smart question-answering, exam marking, intelligent tutoring systems, helping support for students in order to improve their essays, and – possibly – an annotation system for the course materials during their editing process.

At the level of a certain institution platform, it could be considered that a single service provider exists. The collaboration between the institutions can be made within the frame of a service agency, at least for the annotation and retrieval Web services.

IV. Current Semantic Web and E-Learning Annotation Standards

A. Semantic Web metadata specifications

The most important semantic Web metadata standards are the following:

- *RDF* (*Resource Description Framework*) [17] is intended for expressing metadata about the "external" characteristics of a resource: author, type, publication date, copyright, etc.
- *DCMI* (*Dublin Core Metadata Initiative*) [12] provides a set of properties for resource description: <dc:Title>, <dc:Description>, <dc:Contributor>, <dc:Publisher>, <dc:Date>, <dc:Type>, <dc:Subject>, etc.
  The educational version of DCMI still remains at the "external" level of the educational resources characteristics, adding different new elements, such <dc-ed:Audience>, <dc-ed:TypicalLearningTime>, <dc-ed: InteractivityType>, or <dc-ed:ConformsTo>.
- For the Web sites syndication (sharing information with other web sites) purposes, most important standards are *RSS* (*Really Simple Syndication*) and Atom [15].

To express the relations between resources, we can use the following languages, standards and technologies:

- *FOAF* (*Friend Of A Friend*) [14] offers support for expressing only the "knows" relation between persons, but there was developed Relationship – a FOAF Relation specialization is provided by an extension: http://purl.org/vocab/relationship.
- *DOAP* (*Description Of A Project*) [13] defines metadata regarding a (software) project (<doap:Project>, <doap:name>, <doap: homepage>, <doap:description>, <doap:wiki>, <doap:maintainer>, <doap:programming-language>), being based on RDF and FOAF.

The above mentioned formats give support for defining metadata about a Web resource by using external separate files, which could be stored in a distributed manner. For local stored metadata, associated with relatively small resources, the metadata could be "immersed" into Web resources, and there were also established some standards for these purposes:

- *Adobe XMP* (*Extensible Metadata Platform*) – associate metadata to hypermedia documents, making use of XML and a RDF subset;
- *Microformats* [16] – for specifying semantic annotations within XHTML. Some representative microformats are: *hCard* to represent contact information (persons, companies, organizations, etc.), *hCalendar* – for events & timetables, hReview – data about comments made by site visitors, *XOXO* (*Extensible Open XHTML Outlines*) – metadata about XHTML content in order to be facilitated the automatic content processing, *hResume* – information about a resume, *xFolk*, *XFN* (*Extensible Friend Network*) – relations of "friends" (collaborators, relatives, familiars, etc.);
- *RDFa* is a Web Consortium specification providing support for RDF "immersion" in XHTML;
- *XHTML 2.0* will include support for semantic annotations.

mmeybodi@aut.ac.ir

B. E-Learning annotation standards

In the last years, there were made serious efforts in order to standardize the manner of organizing and storing the educational materials ad their metadata. The main reason is the need of making the e-learning content platform independent, in order to be accessible both for humans and computer applications.

Certain of the developed standards address *metadata specification* (ARIADNE, DC – Dublin Core, IEEE LOM – Learning Object Metadata, and ADL). Also, there are available standards regarding the *content structure modeling* – for example, AICC. The IMS and ADL/SCORM standards handle both metadata specification and content structure modeling [9].

Several standards aim to improve the Learning Objects (LOs) reusability. For example, the XML/RDF-based metadata set defined by IEEE LOM and DC (educational version) facilitates Web-based resources retrieval. Furthermore, the IEEE-LOM standard enables developers to extend and add new data elements as required by applications. IEEE-LOM could be used also as the base standard for developing new "application profiles". For this reason, we will consider the Web services proposed below with respect to the e-learning platforms providing support for IEEE-LOM standard.

Based on [1], we mention a classification of the different manners of representing and effectively using the standard metadata in the e-learning applications:

- *Standard Metadata* – certain applications use the standard e-learning metadata (e.g., IEEE LOM) for representing a hierarchical structure, which follows a single perspective; such examples are UK LOM Core and e-mi@ge Project;
- *Semi-Semantic Metadata* – applications that use the IEEE-LOM standard with an extended semantic component; as example, Hypermedia Learning Objects System (hylOs) and <e-aula>;
- *Semantic Metadata* – applications that rely completely on domain ontologies to define their metadata, as examples could be mentioned Edutella peer-to-peer network, or the ARIES Lorner project.

C. IEEE-LOM Standard

The above classification recommends the IEEE-LOM standard as a good framework for our approach. We intend to provide the applications which are using IEEE LOM standard with a support for semantic extension, consisting in annotations based on the semantic Web metadata standards, as well as ontology-based annotations.

Moreover, in IEEE 1484-12-1-2002 standard there were also already established rules for mapping LOM/IMS/SCORM to DCMI educational version [11] – see certain examples in *Table 1*, which are making easy the process of automatically conversion to further standards.

DC.Identifier	1.1.2:General.Identifier.Entry
DC.Title	1.2:General.Title
DC.Language	1.3:General.Language
DC.Description	1.4:General.Description
DC.Subject	1.5:General.Keyword or 9:Classification including 9.1:Classification.Purpose equals "Discipline" or "Idea".
DC.Coverage	1.6:General.Coverage
DC.Type	5.2:Educational.LearningResourceType
DC.Creator	2.3.2:LifeCycle.Contribute.Entity when 2.3.1:LifeCycle.Contribute.Role has a value of "Author".
DC.Format	4.1:Technical.Format
DC.Rights	6.3:Rights.Description
DC.Relation	7.2.2:Relation.Resource.Description

Table 1. Mapping IEEE LOM to Dublin Core Metadata Element Set

V. PROPOSED WEB SERVICE-BASED E-LEARNING ARCHITECTURE

To associate metadata to the Learning Objects – viewed as atomic – or to their component resources, we propose the use of Web services in the spirit of SOA model.

A. Involved Web services

The *annotation Web service* will be activated during the course materials editing.

We present below an annotation scenario. A teacher first starts to edit a new course material, or an existing one. An annotation agent – of those functionalities can be implemented as a service – asks him/her if wants assistance.

If yes, the teacher could indicate a location for storing metadata and could select a list on ontologies for semantic annotations. Another solution – more flexible – is to use *an external Web service for locating the desired ontologies*.

During editing, the service will notify him/her about the automatically generated metadata in semantic Web vocabularies, and will ask him/her some supplementary information – for example, to possibly augment the generated metadata.

Another Web *service* will give the possibility *to match the edited content with certain ontological construct*s – e.g., to attach a given ontological class to a Learning Object or to provide values for different properties associated to a fragment of content (an image, a video document, an animation etc.).

In addition, the system will provide *access to an ontology-based annotation tool* which could be used in parallel with the course editor. In the final, the teacher will find all the semantic annotations stored at the previously indicated location.

Another Web *service will index this location*, and will

mmeybodi@aut.ac.ir

provide it as entry for the educational materials retrieval services. In fact, the system will maintain an annotation database, pointing to the educational resources.

By thus, it provides useful information to be used by a *resource retrieval Web service*, and also this information constitutes a self-description, in the sense of the Web services semantic annotation [8].

B. Semi-automatic generation of metadata

As it could be seen, our scenario involves an *semi-automatically generation of metadata* using semantic Web vocabularies. Our approach consists of automatically translating the suitable IEEE LOM metadata in the most appropriate metadata standard format, according to the vocabularies established by the Semantic Web community – see section 4.

The teacher will be asked to give supplementary information in order to enhance these vocabulary-based metadata. The reason concerns the availability of numerous Web tools developed for processing the standardized metadata formats. Hereby, the course materials metadata could be used not only by the applications providing support for e-learning standards, but also by the general Web applications [3].

Our solution is sustained by the existence of the generic <metadataScheme> element in IEEE LOM, that can include certain sub-elements which could be substituted by certain existing standardized formats for expressing the same information (see also *Table 1*).

C. Additional facilities

Concerning the supplementary creation of standardized metadata (in addition to those already generated), our proposal consider:

- To generate an *Atom* or *RSS* announcement regarding the release of a new educational material;
- To automatically determine all current (possible external) course contributors and collaborators based on the already generated social network of educators via *FOAF* assertions; for each user we can retrieve and point out their microformat-based *hCard* and *hResume* information;
- To build up the *DOAP* description of each educational project.

The process of semantic annotation of the e-learning materials based on the ontologies selected by the teacher could have two components:

- A manual annotation component, which provides the teacher with an ontology-based annotation tool, used at the desired moment: when includes an important notion into the educational material (in form of textual, image, audio or video content), the teacher could browse the ontologies and put that notion into relation with a concept or its properties.
- A semi-automatically annotation component: the annotation service will parse in real-time the content edited by the teacher in order to localize concepts existing in the selected ontologies: when a match is retrieved, the service send to the teacher a notification, asking him to certify if the match is correct or not.

VI. 6. Conclusion and Further Work

The paper provided an overview of a Web service-based platform for annotating e-learning resources.

Following the SOA principles, our approach employs several independent Web services in order to assist the user in his/her activity of annotating educational objects (e.g., presentations, pictures, video documents, additional courseware materials, etc.) by using standardized metadata mechanisms.

Using among other standards the FOAF, DOAP and microformats specifications, the proposed architecture will be able to offer certain social facilities, such as the automatic generation of RSS/Atom feeds or creating the social networks based on user profile.

The paper tried to demonstrate that only a standards-based approach could be a viable solution on the long term in order to develop a flexible and open e-learning Web platform.

Following certain directions provided by [8], our further work will concern the study of real user requirements and detailed architecture of the proposed system.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

E-Learning and ERP as Large-Scale Technological and Organizational Changes in Universities

Dr. Milly Perry
millype@openu.ac.il
Supervisor: Dr. Shoham Snunith
Department of Information Science, Bar Ilan University

Introduction

Universities, the world over, must adapt to daunting social and educational challenges, in which technology is playing a bigger role than ever before – both in inducing changes as well as in providing the means to cope with them. This technology decade had had an impact on almost every aspect of learning and work in academia: research, instruction and administration. Indeed, leading researchers had pointed out that the introduction of any new technology is bound to involve significant changes in work processes and organizational structures, even to the point of reshaping the university's future (Bates, 1999; Duderstsadt, 2000; Guti-Rosenblit, 2005; Kiernan, 2002; Scott & Wagner, 2003, p1). The role of technology in reshaping the university's very essence is pivotal in helping fulfill academia's role as an agent of social and cultural change. Achieving this goal demands mechanism to provide the means whereby decisions will be made regarding organizational and technological shifts that are to determine the university's ability to survive and attract prospective students and staff, particularly in view of the traditional reluctance in some academic circles to embrace changes (Smith, 1999; Elton, 2003).

Objectives

This study presents a cross-section examination of two overall organizational changes introduced into the work processes of Israel's higher education system during the past seven years: E-learning environment and ERP technology. The aim of this work was to describe the manner and method by which technological changes such as E-learning and ERP had been dealt with in universities and with in the Higher education system.

This research uses the "grounded theory" as its methodology.

The higher education system

Educational organizations are qualitatively different from business or commercial organizations. Their management parameters are different, they operate differently, and frequently their organizational values and the criteria for judging the organization's success are also different. The educational organization is considered a "loosely coupled system." This term refers to a situation in which two occurrences share only a few common variables, or the variance between the occurrences pertains to less important variables. Therefore, their common variance is reduced, and the ability to predict one occurrence based on the other is limited (Weick, 1976).

In a loosely coupled system, the sub-systems and their operations are partially linked, yet each sub-system maintains its privacy and independent identity. The parts of the system are attached by a delimited relation of dependency and control.

Theses facts are pertinent also to the link between the organization and the environment. Pressures from the environment or demands for change are "shielded" and do not infiltrate as a parameter that requires the organization to take action. Loose coupling is a characteristic of the structure of academic institutions (Weick, 1976). Educational organizations are defined as having loose couplings between environment, technology, policy, coordination, and supervision. A consideration of the university's culture and structure must take into account not only the traditional university, but also the various models and structures which in recent years have developed into universities of a different nature. A distinction must be drawn between research institutions and colleges, private and government owned universities, and between the traditional and the entrepreneurial universities (Kirp,

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mmeybodi@aut.ac.ir

2003;Heeger,2000;Lueddeke,1999).Nevertheless, despite the variety of universities and the distinctions among them, there are some characteristics that are valid for the majority of universities.

In a study that observed knowledge management at Tel-Aviv University (Perry, 2002), participants described the university as a republic of democracies, or, in the words of a senior director "the organization of Tel-Aviv universities." The high extent of decentralization, the independence of the organization's parts, and the loose coupling between these components define the university's unique functioning and its unique problems. Boyer (1990) claims that the historical, cultural, and structural characteristics of the university create the conditions that prevent it from initiating and establishing an organized and systematic mechanism for managing and assimilating change. At the same time, the university exists in a social and cultural environment that requires it to respond to frequent changes in market demands, budgetary shifts, and technological innovations (Wilms & Zell, 2003; Bates, 1999).

Changes in the higher education systems in Israel and worldwide

Changes that take place worldwide exert an effect on governmental organizations and frameworks, as well as on universities. The forces of change that affect the university are varied (Scott, 2003), and include the following:

A sudden increase in competition due to an increase in foreign, local, and private universities; a significant budgetary cut in government funding due to the change in concept that views public education as a valuable product rather than a service, an expense rather than an investment; public examination and society's demand that universities become significant contributors on an international standard; a demand for life-long learning; and a demand for more efficient management and greater accountability (Lueddeke, 1999). The increased distribution of communication technologies in all walks of life is also influencing the pressures brought to bear on the universities. In the past, universities and colleges held the monopoly on accurate and up-to-date knowledge; nowadays knowledge is accessible through the Internet or through other (payable) venues. Kaiser and associates, (2003) note that "the higher education system has become complex and open to influences from outside the system, both national and international." Other changes are due to the increase in the number of university students, the expansion of higher education institutes that are not universities, the entrepreneurship among private colleges, and the intensive infiltration of branches of foreign universities. Universities find that they must adapt to the rapidly changing terrain of educational institutions, marked by greater accessibility to higher education, more students, life-long learning, integration between studies and employment, more part-time students, a varied student population, and the globalization of learning.

Also in Israel, the universities have had to face changes: "these are considered leading institutions, yet they have to compete for students and budgets. The universities are trying to preserve their status despite budget cuts and increased government intervention" (Guri-Rosenblit, 2002). The demands made on the universities, by the establishment that funds their scientific and cultural activities, for accountability and managerial leadership on the one hand, and the demands made by the market, technology, and the customers on the other hand are forcing the universities to abandon the ivory tower, where they had continued an unchanged existence, and adjust themselves to the environment. The Melz Report for Changing the University's Structure (2000) indicates that the current structure prohibits free flow of information, among its units, limiting the possibility of introducing necessary changes and innovations. "The current structure of most academic institutions is characterized by loose coupling among its academic and functional units. The structure is noted for several essential weak points relates to the work patterns of its units, issues of authority and role allocation, and the reciprocal relations between these components." The report states that the structure of the university does not help it achieve its goals and objectives, is not focused enough to enable it

mmeybodi@aut.ac.ir

to produce an optimal outcome, and in fact hinders its ability to perform necessary tasks. " (The Melz Committee Report, 2000). In this report, "the government of Israel decided to assign the Chair of the Council for Higher Education the task of preparing a plan for changing the managerial-organizational structure of every university in Israel. This plan would clearly define areas of responsibility, authority, and function to each administrative body (Pazzy, 2002).

In 1999, the Planning and Budgeting Committee of the Council for Higher Education appointed a sub-committee to oversee the implementation of information systems in institutes of higher education. The Committee concluded that technology integration is significant for the processes of teaching and learning, research, and the development of high-tech industry, and that without designating funds and creating incentives for this specific purpose, the universities would not initiate a methodical move for technology integration (Appeal of the Planning and Budgetary Committee, 1999). The report also states that "in the university organization there is a gaping need for operations involving innovative technologies. The existing infrastructure for information systems requires a comprehensive vision as well as role allocation for an information systems administrator, as in large business systems and various large universities throughout the world." This would help universities attain their goals and respond swiftly to changes in the scientific, social, and economic environment in Israel and abroad. A "top-down" strategy for handling organizational changes in the university is a major vehicle for managing change in higher education, where " most layers of management and knowledge employees are isolated from environmental demands and from the administration thanks to their tenured status and the important feature of "academic freedom," which provides the pretext for separate departments to reject the university administration's decisions. The "top-down" strategy has borne positive results in terms of change implementation and technology integration in teaching and management processes" (Wilms & Zell, 2003).

Technological changes in the higher education system in Israel

A U.S. report on the "Future of Research University" (2002) states that digital technology will change not only the intellectual activities of a research university but also its organization, funding, and management. This technology will establish a link between the higher education and the high-tech sectors, including publishing, communications, and entertainment, creating an industry of learning and knowledge. Recently, such optimistic expectations have been replaced by budgetary problems among universities worldwide, including in Israel. In their attempt to difficulties in system management, some universities find in technology a means for coping with the changes and difficulties ahead. Others try to make more efficient use of advanced technologies. As mentioned, in 1999, the Planning and Budgetary Committee announced a competitive appeal for universities to submit a proposal for integrating technology in learning and teaching with a corresponding proposal for funds allocation. The appeal encouraged proposals that would integrate technology in learning and teaching, academic management, and administrative processes. Universities whose proposals would be accepted would be rewarded with expanded budgets. These developments set in motion two organizational-technological changes that were implemented in Israeli research universities in the last five years.

The process of e-learning is televised (usually through the internet). It is a significant technological component in the learning processes, which forms part of accreditation courses in most degree programs and disciplines available at Israeli universities. E-learning is a high-tech didactic method, in which communications and the computer are inherent components of the ability to perform the learning process. A didactic process is part of the university's academic activities performed by the academic staff and supported by technological and administrative units.

The second organizational-technological change implemented is Enterprise Resource Planning (ERP) for managing the organization's resources.

"ERP implementation relates to the software-

mmeybodi@aut.ac.ir

based infrastructures that contain internal organizational information (e.g., employees, work procedures, etc.) and external organizational information (e.g., procedures for handling suppliers, students, etc.) pertinent to the organization as a single system" (Abereed Group, 2004). The ERP system manages the entire array of organizational resources, enabling management of information across the organization in a database shared by all university departments and encompassing all of the university's activities. This process is considered particularly useful for the organization's administrative activities.

Both processes have been implemented in all of the universities in Israel in the last five years. These institutions are at different stages within the implementation process (some have completed it and are applying these technologies on a regular basis, others are in the middle of the process, and yet others are just completing its initial stages. There is variance in the degree of implementation of the two technologies (e-learning implementation is more advanced than ERP implementation). The particular technological products selected for the application of e-learning and ERP differ from one institution to another, as do their prior experiences with technology and their choices for its current application. Despite the existing variance pertaining to many of the parameters in the process, it is apparent that all of the universities in Israel did apply these organizational-technological changes.

Method

The research used in-depth interview as its main tool. The main target audience were Academic managers, technological managers and academic stuff. Managers from higher education regulation organization have been interview to this research as well.

The study focuses on methods for enhancing initiatives for large-scale technological changes, both inside and outside the university, their formation, progress, and management, including repercussions that any one university's decisions have on other universities. This study sets out to clarify what, if any, models and methods are devised for managing, navigating and adjusting academia in an ever-changing environment, while considering its unique functions and culture.

Methodology

The Constant Comparative Method is an inductive method for theoretical discovery (Sabar Ben-Yehoshua, 1990) that will be used as the basic research method. The method includes systematic encoding and analysis of a theoretical model intended to render a comprehensive, integrative model that remains consistently close to the data. This method provides a flexible space that facilitates the comprehensive and creative construction of the theory. The Constant Comparative Method includes five stages:

Stage 1

Primary categories identification and definition and theoretical sampling stage

At this stage, which is termed the stage of open encoding, I analyzed the initial research findings, locating recurrences of themes, subjects, or titles that appear repeatedly and can be characterized or named. Data were divided into themes or topics, according to the analytic units determined these "themes" will be considered "primary categories."

Stage 2

Categories formulation, definition of criteria, and continued sampling

This stage, termed the "stage of axial encoding," I performed an analysis according to the axis of the previously defined categories, and continue to improve and provide a more accurate definition of categories.

Stage 3

Criteria and definition refinement and categories final system. This stage, termed the "stage of directed encoding," I continued collecting data and encode them according to the existing system of categories, in order to increase the internal validity of findings. By increasing the amount of data for each category I verified that the structures and criteria actually exist in the reality studied.

Stage 4

Creating a hierarchy of categories -. At this stage I found various ways to link all categories and

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criteria. I explained and interpret one category by referring to another, and consider which categories constitute a cause and which ones are the effects.

Stage 5

Creating a theoretical structure, connecting to research literature and theory

At this stage I described the findings and conclusions in theoretical terms, i.e., using research terminology. This is the highlight and culminating point of the process of analysis: constructing a matrix of circumstances, a system of spheres that locate the researched phenomenon and the site studied, using the most broad and universal terms available.

Findings

Data emerging from research (category and sub-category)

Sharing and learning: Info, cooperation and collaboration

Change factors: internal and external: near, above, inside, distant

Change agents: initiators, catalysts, assimilators, leaders

Change leader: identity, seniority, personality Professionalism,

Diagnosis and mapping

Targets: Organizational targets / change targets

Change management

Objections: power, source, kind, identity

Nature and subject of change: e-learning, ERP

Message transfer: communication, support and sharing

Mega-category and sub-category system

Mega-category	sub-cat.	sub-cat.	sub-cat.
Change factors	internal factors	external factors	change targets
Change agents	change agents	change leader	
Nature of change	nature of change		
Change mechanism	examination and mapping	sharing & learning	change process message transfer objections

Conclusions

One of the main findings was that overall organizational changes in Israeli universities are taking place without a clear and well-planned model. Moreover, there are no methods or guidelines, nor so much as a know-how tank in any of the regulatory systems inside or outside the universities. There is large understanding in the universities regarding the change agents, change components, change leaders, nature and subjects, but very little understanding regarding to the change mechanism and process.

The research data yielded that there is a sort of a mechanism (not pre-conceived) for large-scale technological and organizational change management in Israeli universities. This mechanism acts within universities or in close proximity to universities as a CoP (community of practices) and is influenced by other universities' decisions. Information which reaches the CoP of professionals (a forum in which every university has one representative) serves as a change catalyst. In the process of receiving and processing information, CoP's members are addressing all relevant issues: difficulties, problems, misgivings. They thoroughly map all information while looking at different options to solve particular problems (Drawing on experience accumulated in Israel and abroad). After consolidating their decisions they push for implementing various changes in their own institutions or in the higher education system, as a whole. They do so by lobbying, sharing and promoting the change benefits and providing guidelines. Any implementation of a given decision could in turn set the whole process in motion again.

The study in fact established that this process was rather non defined and diffused as far as methods or pre-conceived goals were concerned. It emerged rather as a Knowledge Management process. On the basis of this understanding, it would seem imperative to devise a pre-conceived and well-planned model that would enable efficacious large-scale organizational and technological change management. The model we propose is facilitating knowledge management strategies and process for achieving change management: KM-M-CM: (**K**nowledge **M**anagement as a **M**echanism for **C**hange Management).

The model draws on existing processes (mostly partial) and sets out to formulate them in a methodical, rationally-sound, and pre-planned

mmeybodi@aut.ac.ir

framework. This model will achieve two targets: firstly, establishing a **well planned** mechanism for managing large-scale technological changes, **previously non-existent**. Secondly, devising a **new mechanism** based on **existing processes** in the university's organizational and environmental practices.

The implementation of this model will facilitate transforming the university from "a know-all organization" into a "learning organization". It could be accomplished once Israeli higher education policy makers fully grasp the need for a permanent mechanism for change management and are willing to adopt the suggested model.

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mmeybodi@aut.ac.ir

Experience with Pedagogical Patterns in Introductory Java Course

Mirela Djordjevic
Manhattanville College
Department of Mathematics and Computer Science
Purchase, NY 10577
djordjevicm@mville.edu

Abstract- **The purpose of this paper is to share our experience with a pedagogical pattern – spiral model in teaching diverse concepts (structural, object-oriented, visual) of an introductory Computer Science (CS) course in Java. Some other patterns are also used: *early bird, test tool, grade it again Sam*. At the beginning, the paper clarifies some colloquial or conventional characteristics that distinguish CS programming courses particularly for Liberal Arts. Following this, it reviews in general terms the selected pedagogical patterns used for teaching computer science courses and programming. Finally, the paper recommends the spiral method of Java topics that are covered in an introductory programming course and reports on the teaching experiences during four semesters.**

Keywords: Java Programming, Introductory Programming Course, Pedagogical Patterns, CS2001 Java Task Force – CS for Liberal Arts

I. INTRODUCTION

As a part of the curricular revision process, colleges and universities utilize a variety of criteria to help decide how to teach the Introductory programming course faced with the basic problem that computer science program in liberal arts must meet a number of diverse needs. Often the introductory programming course must satisfy the need for computer literacy as well as to serve more advanced students who need to continue the computer science as their own discipline. Manhattanville College program serves an academic community of 1,200 students. Almost one tenth of the student body enrolls in a programming course before they graduate. Some students take introductory programming course for their distribution requirements, some take it for fun e.g. to use graphics, and some continue their major in computer science. This is a diverse group, for whom introductory programming course in Java is "The hardest course in their college career", which requires them to "learn to think in a completely different way". In addition to the diversity of student backgrounds, also the highly technical nature of programming *per se* makes it difficult to master. To design, implement, compile and test even a small program requires a wide array of specific knowledge and skills ranging from the syntax and semantics of the programming language, to problem solving strategies and software design principles. Further, the proficiency in the use of computer software tools such as editors, compilers and debuggers is a must. For some students, however, even logging into and using an unfamiliar computer system is a challenge.

Viewed from the Computer Science Consortium [6], the CS requirements for introductory programming course are the following: teach object oriented programming from the very beginning of the course – start with object and classes, Fundamental programming constructs (basic syntax and semantics of a higher-level language, variables, types, expressions, and assignment, simple I/O, conditional and iterative control structures, functions and parameter passing) and event-driven programming **(**event-handling methods, exception handling).

How to reconcile students' needs and goals, at one hand, and curriculum requirements, on the other hand, in effective teaching? We describe our introductory programming course and the success that we have had teaching them using a disciplined approach to programming with the spiral model [3] of teaching and several pedagogical patterns [4]: Early bird, Test tube, Mistake, Grade it Again Sam.

II. PEDAGOGICAL PATTERNS

We review the basic explanations of the selected pedagogical patterns [4] that we incorporated in teaching introductory Java course:

Spiral Model - Topics in a course are divided up into fragments and the fragments introduced in an order that facilitates student problem solving. Many of the fragments introduce a topic, but do not cover it in detail. Just enough detail is given initially so as to form a basic understanding that can be applied to problem solving. Additional cycles contain reinforcing fragments that go into more detail on the topic.

Early bird - Teach the most important material, in case of Java - "objects," first. Java objects and classes are taught as soon as possible. They are introduced at the very beginning of the course and their usage and definition are reinforced in various circles of the spiral model.

Test tube - Students can answer their own "What if…" programming questions with access to a computer. Sometimes this is quicker and more effective than formal documentation. Students can also explore the undefined parts of some computer languages. Teaching in the computer laboratory gives an opportunity to practice this pattern by modifying the existing code.

Mistake - Students are asked to create an artifact such as a program or design that contains a specific error. Use of this pattern explicitly teaches students how to recognize and fix

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 338–341.
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errors. We ask the student to explicitly make certain errors and then examine the consequences. We regularly practice to show the errors that appear during the class time with some students and explore the message from the system and the reasons for error occurrences.

Grade it again Sam - To provide an environment in which students can safely make errors and learn from them, we permit them to resubmit previous assignments for reassessment and an improved grade.

Most of the previous patters make the learning process active, collaborative, and effective, which has been known as the best learning. It takes place when the students are actively involved in the learning process and are critically thinking. As an old Chinese proverb states: "I hear and I forget. I see and I remember. I do and I understand" [9].

III. ENVIRONMENT

Traditional textbooks take a path by introducing syntax of the language first, structures (assignments, selections, methods and loops) and then in seventh or eighth chapter cover topics as objects and classes, and event-driven programming - even further in the book. This approach commonly uses command line output – which is a "burden" for our students, and they are simply lost in the tedious syntax and imperative programming paradigm

Object-oriented textbooks (titled "objects first") offer different approach – objects first that introduce classes and objects at the very beginning, and then in the tenth or eleventh chapter explore the graphical user interface (GUI) and environment and visual object usage. This sequence is acceptable, but hardly managed for one semester course that intends to set the basic constructs of the structures, syntax, objects and event- driven programming. Students go through the course without ease and they are missing the fun of being attracted with visual effects of forms, buttons, etc.

Our department has made changes in teaching to make it more attractive and hopefully "easy and more fun" by using the visual objects and event-driven programming. In particular, NetBeans environment offers easy development of GUI and we have been using it and its versions for the last five years. Students were required to work on the lab projects that are well-defined – but they could hardly build these by themselves, as the textbooks could never follow the approach that we tried to establish – a good balance of object oriented notions, Java syntax, and visual objects with event driven programming. Our labs were fun for students when they could see the result, but they were not following any book. Students were mostly doing "copy & paste" without being active participants in the process of creating solution for the lab projects. Some students were confused with many different concepts in the area that is already marked as the "hardest course" in their college education.

In 2004, we made another goal – teach objects and classes first. We explored this by defining the classes and using the objects, and then introduce the methods and selections. Again, the course was interesting for hard working students, but widely recognized by others (once again) as the "hardest course".

In our curricular revision process during 2005/2006 we proposed a vivid approach – using graphics in the course, as the quantitative knowledge of our students is small. Calculations and mathematical examples previously used were discouraging for our students, as they required learning mathematical problems. This models our course around the graphics objects and lead to introducing the graphics objects and class the very first week of the semester.

Also, we proposed to use iteratively all of the components, according to the schedule (scheme): teach object oriented programming from the very beginning of the course – start with object and classes, imperative paradigm (variables, assignments, methods, classes, objects, loops), event driven programming, use graphical user interfaces and slowly integrate them throughout the semester. Our decision was also to practice the described pedagogical patterns.

IV. SPIRAL MODEL IN USE

Understanding Object-Oriented terms, topics and terminology is essential to fully understand Java programming language, as Java is built around methods, objects,

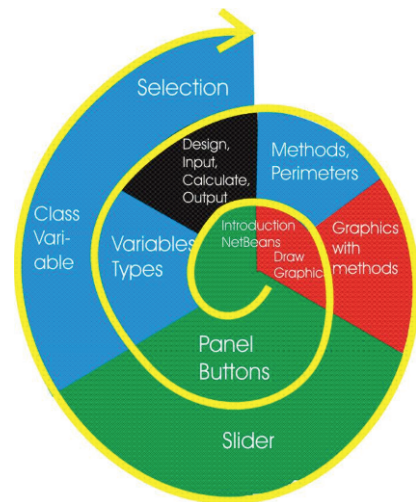


Fig.1. Phase 1 starts by introducing NetBeans as the environment and build the first projects by using the library Graphics object, and continues within the Spiral Model to introduce controls, events (green color), fundamental concepts (blue color), classes(red color) and basic algorithms (black color).

instantiations and such. According to our experience, the recommendation is to teach the features that are basic to all programming languages such as program syntax, arithmetic operations and control structures, "mixed" with the specifics of the object oriented terms and visual controls. Thus we teach objects and classes, and event-driven programming later in the course, but use them at the very beginning of the course.

mmeybodi@aut.ac.ir

As students have already used some Windows applications and they are familiar with buttons, button click events, text boxes and labels, mouse click events, i.e. with event driven design, the recommended approach is to use ***a minimal set*** of these visual objects from the very beginning of the course. When the *User defined classes* are introduced, we make comparisons of the *JButton class, JTextField class* and *User defined classes* to establish the commonalties and to follow the pattern of set and get methods.

We start by introducing NetBeans as the environment and build the first Windows Application that draws shapes (circles, squares), shown on Fig. 1 in the center of the Spiral Model.

Clearly on the figures, fundamental concepts are depicted with blue color, objects and classes with red and visual controls with green color .Black color is used to denote the basic concepts of algorithms and problem solving. The innermost part of the spiral model denotes the introduction of the environment and programming.

The students use the library class Graphics and its methods without explaining details, and explore the effects of drawing with concrete numbers and change the colors. Next they work on a similar drawing project with drawing circles, lines, squares that are colored and filled with color.

We introduce variables and types (*int* and *double*), follow with methods to draw the shape consisting of circles and squares at different points on the panel. Class variables are added when there is a requirement to change the color of the shape together with the radio buttons or check boxes.

Making selection is explored with the *if* and switch statements when we ask the students to draw different shapes on the panel and use different colors for drawing.

In phase 2, we continue with interleaving different concepts:

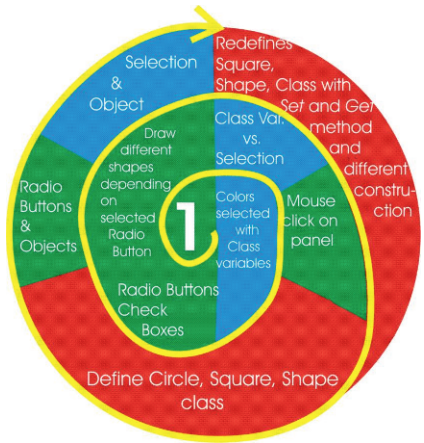


Fig.2. Spiral Model's Phase 2. continues Phase 1.

radio buttons, check boxes, and the default events. Further, we compare the usage of class variables and selection statements. The major topic in the phase 2 is user defined classes, and their integration with all other concepts defined in phase 1. So, we repeat the concepts from Phase 1 (radio buttons, slider, methods) with the user defined classes and then redefine the user defined classes by adding different constructors, set and get methods.

Finally, we show phase 3 with the main topics – loops and collections. We introduce loops to draw shapes horizontally (vertically, diagonally) and display some data about the shapes in the text area. We also find maximum and minimum values of the x and/or y coordinates of the drawn shapes using the class variables. Then, the collections of shapes are made with *ArrayList* objects, and we ask the students to find the range of

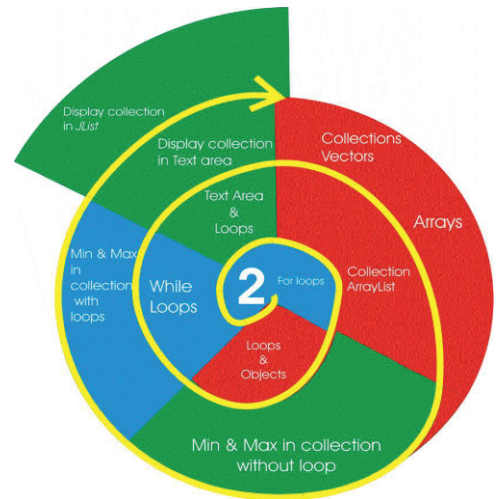


Fig.3. Spiral Model's Phase 3. continues Phase 2.

values of y coordinates of the stored shapes.

Collection is then stored as Vector object and displayed in *JLists*. A mouse click event on the *JLists* asks for accessing the selected element and makes some modifications on it.

At the end of phase 3, we define arrays and make array of shape objects and repeat the same set of operations (find minimum, maximum of the particular shape values) and display them in *JList*.

Occasionally, we add non-graphics examples to clarify the constructs. For example, when we discuss class variable, we explore the task of calculating the average grade while the grades are entered through the input box, or text field, to explore class variables. Or, when we discuss the collections – *ArrayLists* and Vectors, we add the example of student objects and calculate the average grade (grade min, max).

V. TEACHING EXPERIENCE

The way we teach is with the progressive projects. We started with a small set of statements, visual controls, and predefined classes in a simple project of drawing, and extend this set through the requirements of the subsequent projects. In

mmeybodi@aut.ac.ir

each of the projects we made a clear need of extending it, and that is performed in the subsequent project. This is our implementation of the spiral model of teaching in introductory programming course and effective teaching as grades' increase (numeric average grade went up from 76.69 to 91.05 and there is 40% - 50% - more As and Bs). The summarized data are shown in the Table 1.

TABLE I
GRADES IN FALL 2005 AND SPRING 2006

	Fall 2005	**Spring 2006**
Average grade (range: 1-100)	76.69	
Percent of As and Bs	47.06%	29.41%
	Fall 2006	**Spring 2007**
Average grade (range: 1-100)	85.23	91.05
Percent of As and Bs	84.61%	81.25%

Students attended lectures enthusiastically and were able to work on the problems. They were not frustrated with the hardest course. Students increased their confidence with the workloads.

Students' comments on the course in fall 2005 were:

"Only if they are interested in computer programming, it is too difficult to just take for fun." or *"I loved this course, but it is difficult if you have no computer language experience*".

And in spring 2007 more students reported that the course was interesting as:

"*The course is interesting because it has completely different methods all together*" or "*Very interesting and challenging*".

Obviously, students' comments are encouraging. They lead us forward to establish more firm models and to continue our endeavor in the direction determined by this research.

Fig. 4 shows our relevant data during four consecutive semesters.

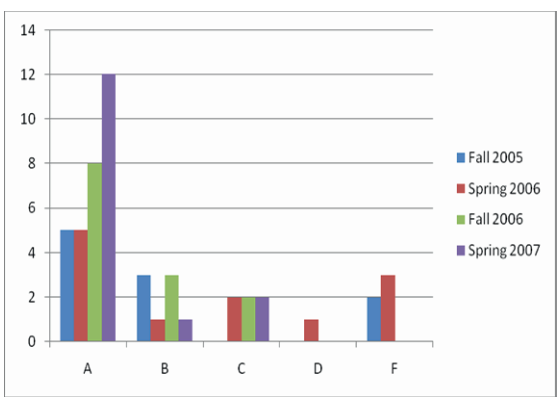


Fig. 4. Grade's distribution through semesters: Fall 2005 - Spring 2007

As an old Chinese proverb states: "*I hear and I forget. I see and I remember. I do and I understand*".

VI. CONCLUSION

Although the pedagogical patterns described in this paper were used to address teaching in a class of students of diverse backgrounds in a first Java programming course, the results show that the ability to handle variety of components and repeating some concepts with same tasks increases teaching effectiveness. This paper described the Spiral Model of teaching in use and blends a need to know within a circle of competence. The model and its implementation are designed to handle students with varying backgrounds and learning styles. Promising reports in students' attitudes, grades and satisfaction are shown in the results

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mmeybodi@aut.ac.ir

Automating The Work at KAI-RCS: A Case Study on Using an Imaging Database to Optimize the Selection Process of Projects Team Members

Mohammad AbdulRahman ALGhalayini [1] and Mohammad ALIssan ALGhamdi [2]

[1]Director, Computer and Information Unit, Vice Rectorate for Branches
King Saud University, Riyadh, Saudi Arabia
[2]Dean, King Abdullah Institute for Research and Consulting Studies
King Saud University, Riyadh, Saudi Arabia

Abstract

Today, many institutions and organizations are facing serious problem due to the tremendously increasing size of documents, and this problem is further triggering the storage and retrieval problems due to the continuously growing space and efficiency requirements. This problem is becoming more complex with time and the increase in the size and number of documents in an organization. Therefore, there is a growing demand to address this problem. This demand and challenge can be met by developing a process to enable specialized document imaging people to select the most suitable image type and scanning resolution to use when there is a need for storing documents images. This process, if applied, attempts to solve the problem of the image storage type and size to some extent. In this paper, we present a case study resembling an applied process to optimize the selection of project team members in King Saud University King Abdullah Institute for Research and Consulting Studies by collecting university faculty and staff information and CV's and store them in an imaging database to make the retrieval of information and CV's scanned images easier and faster; therefore, we optimize the work process and maximize the efficiency of KAI-RCS tasks.

Introduction

KAI-RCS is King Abdullah Institute for Research and Consulting Studies. It is officially responsible for handling any researches, studies, or consultation projects required by King Saud University specialized members by various external governmental and private sector institutions; therefore; the main duty of KAI-RCS is following up these projects from their initial marketing stage till the end of the contract duration period.

As an official KSU institute, KAI-RCS is responsible for organizing and administering any consultation projects required by any outside institutions, KAI-RCS was having a considerable difficulty in forming a project team specialized in the area of the required project or even in fairly nominating a project team leader since the information of KSU faculty and staff members were not directly known and were not directly accessible by the institute officials. This case was affecting the effectiveness of KAI-RCS's main duty since forming a team used to take days if not weeks in some cases and therefore loosing a good project was possible or at least unfairly forming a team since not all specialized faculty and staff members were considered equally or remembered during this process.

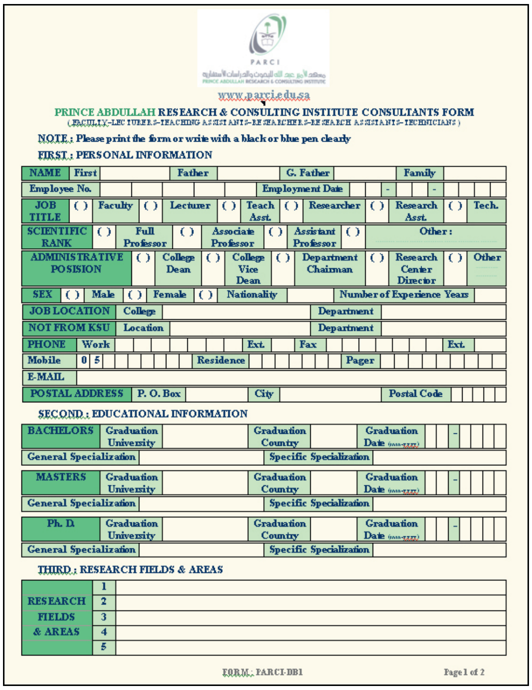
A database system to include the information of KSU faculty members and staff was a must to make it easier and faster to refer to any specialized KSU members and review their CV's and previous academic experience.

Solution Steps

1 - A form of two pages was properly designed and distributed to all 110 KSU departments by a dedicated KAI-RCS employee. **Figure (1)** and **Figure (2)** below show the designed information form.
2 - A document scanner and a high specs PC were bought in preparation to be used when those forms and attached documents start to arrive back at KAI-RCS.

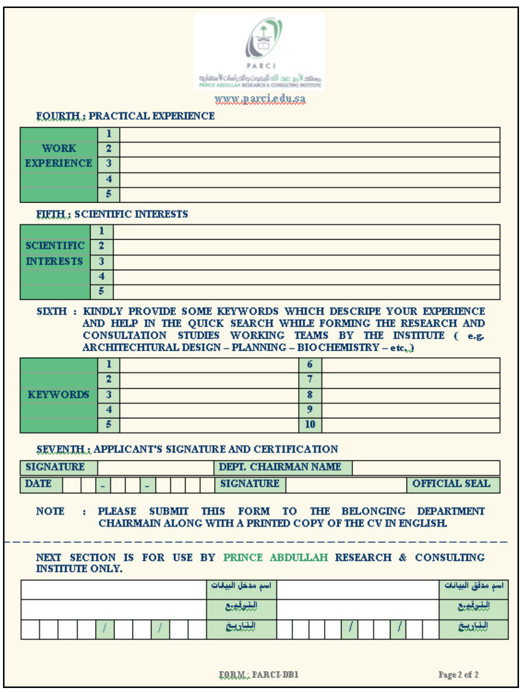
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NOTE : Please print the form or write with a black or blue pen clearly
FIRST : PERSONAL INFORMATION
NAME | First | Father | G. Father | Family
Employee No. | Employment Date
JOB TITLE | ( ) Faculty | ( ) Lecturer | ( ) Teach Asst. | ( ) Researcher | ( ) Research Asst. | ( ) Tech.
SCIENTIFIC RANK | ( ) Full Professor | ( ) Associate Professor | ( ) Assistant Professor | ( ) Other :
ADMINISTRATIVE POSISION | ( ) College Dean | ( ) College Vice Dean | ( ) Department Chairman | ( ) Research Center Director | ( ) Other
SEX | ( ) Male | ( ) Female | ( ) Nationality | Number of Experience Years
JOB LOCATION | College | Department
NOT FROM KSU | Location | Department
PHONE | Work | Ext. | Fax | Ext.
Mobile | 0 5 | Residence | Pager
E-MAIL
POSTAL ADDRESS | P. O. Box | City | Postal Code
SECOND : EDUCATIONAL INFORMATION
BACHELORS | Graduation University | Graduation Country | Graduation Date (mm-yyyy)
General Specialization | Specific Specialization
MASTERS | Graduation University | Graduation Country | Graduation Date (mm-yyyy)
General Specialization | Specific Specialization
Ph. D | Graduation University | Graduation Country | Graduation Date (mm-yyyy)
General Specialization | Specific Specialization
THIRD : RESEARCH FIELDS & AREAS
RESEARCH FIELDS & AREAS | 1 | 2 | 3 | 4 | 5
FORM : PARCI-DB1 Page 1 of 2

Figure (1) Shows side-1 of the designed information form.



PARCI
PRINCE ABDULLAH RESEARCH & CONSULTING INSTITUTE
www.parci.edu.sa
FOURTH : PRACTICAL EXPERIENCE
WORK EXPERIENCE | 1 | 2 | 3 | 4 | 5
FIFTH : SCIENTIFIC INTERESTS
SCIENTIFIC INTERESTS | 1 | 2 | 3 | 4 | 5
SIXTH : KINDLY PROVIDE SOME KEYWORDS WHICH DESCRIPE YOUR EXPERIENCE AND HELP IN THE QUICK SEARCH WHILE FORMING THE RESEARCH AND CONSULTATION STUDIES WORKING TEAMS BY THE INSTITUTE (e.g. ARCHITECHTURAL DESIGN – PLANNING – BIOCHEMISTRY – etc.)
KEYWORDS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10
SEVENTH : APPLICANT'S SIGNATURE AND CERTIFICATION
SIGNATURE | DEPT. CHAIRMAN NAME
DATE | SIGNATURE | OFFICIAL SEAL
NOTE : PLEASE SUBMIT THIS FORM TO THE BELONGING DEPARTMENT CHAIRMAIN ALONG WITH A PRINTED COPY OF THE CV IN ENGLISH.
NEXT SECTION IS FOR USE BY PRINCE ABDULLAH RESEARCH & CONSULTING INSTITUTE ONLY.
اسم مدقق البيانات | اسم مدخل البيانات
التوقيع | التوقيع
التاريخ | التاريخ
FORM : PARCI-DB1 Page 2 of 2

Figure (2) Shows side-2 of the designed information form.

3 - A database was designed, implemented, and tested to be used to store the forms information as well as the scanned documents belonging to each KSU faculty or staff member.

4 - By the time the database system was ready, a dedicated KAI-RCS employee started to collect the forms and the attached documents from all KSU departments according to a predefined time schedule.

5 - The data entry person who was previously trained on using the database system was ready to receive the forms with any accompanying documents and arranging them in folders categorized by colleges and departments for easier referencing.

6 - Each time the data entry employee used to come and scan the filled form and the corresponding CV of the faculty or staff member then store the form in a folder and store the CV in another folder on the local hard disk. Both of those folders where stored in a parent folder having the name of the faculty or staff member. That parent folder was a part of other similar folders in a parent folder having the name of the department[1]. That department folder also was one of other department folders contained in a folder having the college name.

7 - When the faculty member data was ready to be entered, all what the data entry person worried about is storing the information of the form as text in the database system corresponding fields and storing the previously saved scanned image of the form in the OLE field in addition to storing the CV file (which was scanned and stored previously as .max file or as a PDF file on the local hard disk) in the proper OLE field[2].

8 - After storing one full form information and storing scanned documents belonging to that record, the form is signed and dated by the data entry person, then stored back in the paper folder it belongs to. This step was necessary to easily figure out which forms where completely entered and which were not.

9 - Each week end, a complete copy of this database system was backed up on the central file server to be accessed by KAI-RCS authorized persons. In addition to saving a backup copy on a writable CD.

Special Notes About KAI-RCS Experts And Consultants Database System

This system was designed using MS-ACCESS RDBMS which is one of the MS-OFFICE applications.

1 - It was taken into consideration making this system a very user friendly and totally in Arabic language and easy to use as much as possible.

[1] This hard disk arrangement made it easy to quickly reference any stored document images and retrieve them when necessary.
[2] Object Linking and Embedding.

mmeybodi@aut.ac.ir

2 - All KAI-RCS PC's were updated to have 512 MB of RAM at least and 64 MB display memory to access the system conveniently.
3 - All KAI-RCS PC's were connected through network to being able to connect to the dedicated central file server (KAI-RCS_SERVER) with a special user name and password for all authorized KAI-RCS employees.
4 - The system is accessible through a password for security reasons.
5 - It is possible to print any page or pages of the documents stored in database system on the central color laser printer, which is directly connected to the server.

Contents and Data Security

Since the KAI-RCS system may contain some private information which could be confidential, it was necessary to the KAI-RCS member including the data entry employee, to keep a special system password to use it to access the system whether from his own pc in the office or from connecting to the server from outside KSU campus. And even though the server could be seen to others on KSU network but it was not accessible to any unauthorized person; therefore, the system was also not accessible to any unauthorized person.

One more thing regarding data security is the issue of weekly backup of the whole database system including the stored documents images on the server hard disk and on a removable writable CD.

Hardware Used

1 - PC with the following specifications:
2.8 Mhz Intel processor
1024 MB DDR RAM
80 GB WD Hard Disk
128 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor
2 - Image scanner with the following specifications:
40-60 pages per minute
Simplex / duplex
Black and white and color scanning
3- Central file server with the following specifications:
2.8 Mhz Intel processor
1024 MB DDR RAM
80 GB WD Hard Disk
128 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor

Software Used

1 - Windows XP on data entry PC
2 - Windows 2000 server on the file server
3 - PaperPort 9.0 professional version for scanning images on the data entry PC.

Time Consumed

As an automation project, there was a dedicated and limited time to finalize the project. The central database containing the images of the filled information forms and the stored CV's, was ready to service KAI-RCS users after the first day of data entry phase (phase 6). Collecting the filled forms from the university various departments was distributed on a couple of employees as a daily process for 6 weeks simultaneously with the process of database system design, implementation and testing.. The following table shows the time consumed to finalize such an automation project.

No.	Process	Time consumed
1	Designing the information form	1 week
2	Distributing the form to 110 KSU departments.	3 weeks
3	Buying and setting up the hardware.	3 weeks (simultaneous with phase 2)
4	Database system design, implementation and testing.	6 weeks
5	Collecting the filled information forms from the university various departments	6 weeks (simultaneous with phase 4)
6	Data entry	10 – 15 complete records per day

Table (1) Shows the time consumed for each process of the specified project

The Optimized Search

Although MS-ACCESS which is the RDBMS system used to implement the needed database application provided a powerful build-in search option which was enough to search in almost any field; however, the designed information form included 10 key words fields to be filled by the KSU expert and therefore filled in the database corresponding fields.

These 10 keywords provided great search benefit in filtering any records according to the user entered keyword or combination of key words. The resulted number of records based on the query used could vary from 0 to total number of records stored but in most cases it gave a precise number of records that

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could be browsed as far as information and research history as well as being able to view their corresponding CV's. This capability gave this database application it's power since it reduced the time of generating team members to great extents with fair mechanism for selecting projects team members as well.

Screen Photos of the KAI-RCS Experts and Consultants Database System



Figure (3) shows the main data entry form after passing through the authorization screen. The green field indicates the primary field[3]. The user may use the command keys on the bottom of the form to manipulate the data or/and add new records. In addition, the user could use the search keys to search through the previously stored faculty records.



Figure (4) shows the educational and the research information fields to be entered by the data entry person according to the filled form. In addition to the scanned image of the form OLE field which is to be entered as an embedded object from where it is previously saved on the local hard disk.



Figure (5) shows the practical experiences and the scientific interests information fields as well as the keywords fields to be entered by the data entry person according to the filled form. In addition to the scanned image of the CV OLE field which is to be entered as an embedded object from where it is previously saved on the local hard disk.



Figure (6) shows the practical experiences and the scientific interests information in addition to the keywords fields to be entered by the data entry person according to the filled form. In addition to the scanned image of the CV OLE field which is to be entered as an embedded object from where it is previously saved on the local hard disk. Projects participated in for this specific faculty person may be entered and browsed through in this form also. The data entry person information fields are also required in this form for validation purposes.

[3] Primary keys are used in databases tables to avoid duplication of records and to ensure data integrity and consistency.

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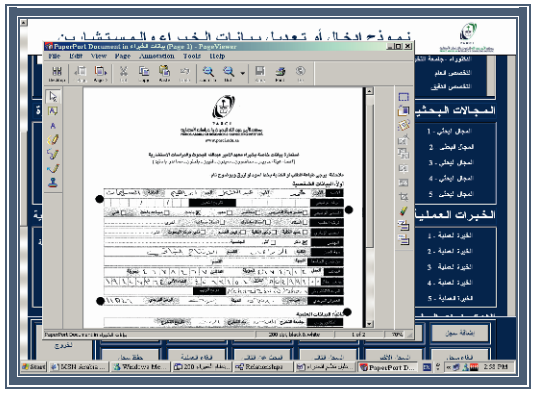


Figure (7) shows a display of the faculty information form which in this screen was activated by PaperPort[4] software used to scan documents and store them as one or multi-pages in .max format as a one object in the OLE field.



Figure (8) shows the ability to embed or link the OLE object which is a scanned image of the form or the CV, here the inserted object was chosen to be displayed as icon in the field of this data entry form.



Figure (9) shows the MS-Access built-in search facility. In this case, searching in the project number field for a specific project. Information of projects which this expert participated in previously means previous experiences for this nominee. This was helpful in making a decision on nominating this person to be a team membership for the current project.



Figure (10) shows the first summary report screen of the faculty and staff records saved in the database in addition to the total number of records. The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.



Figure (11) shows the detailed information screen of a faculty record after pressing on right most button displayed next to the record.

[4] PaperPort is a trade name of ScanSoft Inc.

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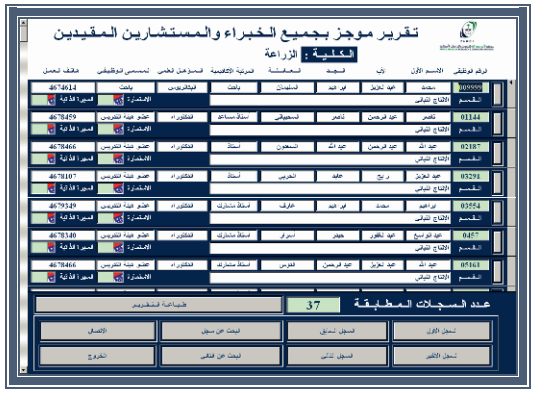


Figure (12) shows the summary report screen of the faculty and staff records saved in the database in addition to the total number of records belonging to the selected college. The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.



Figure (13) shows the summary report screen of the faculty and staff records saved in the database in addition to the total number of records belonging to the selected college and department. The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.

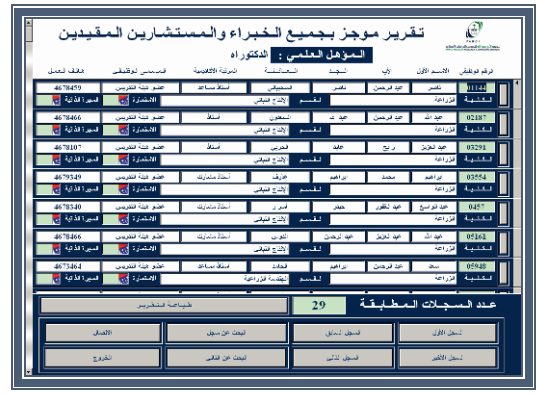


Figure (14) shows the summary report screen of the faculty and staff records saved in the database in addition to the total number of records belonging to the selected academic qualification**.** The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.

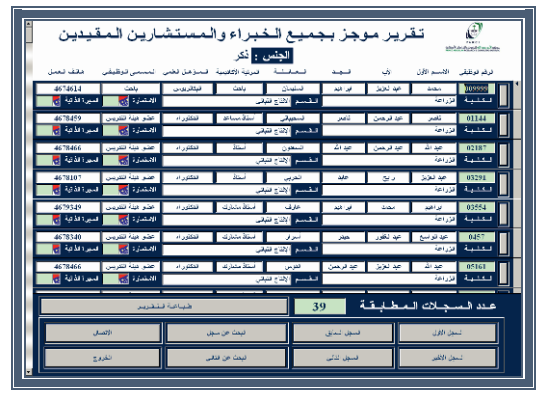


Figure (15) shows the summary report screen of the faculty and staff records saved in the database in addition to the total number of records belonging to the selected sex**.** The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.

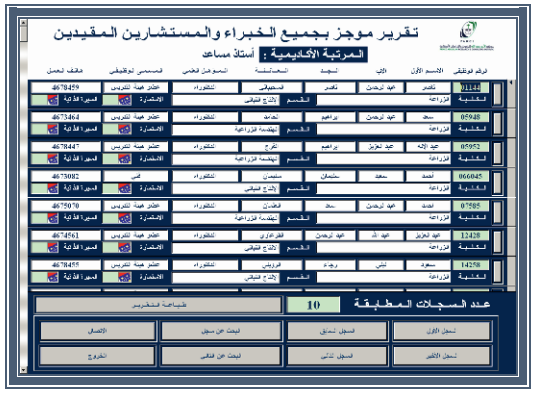


Figure (16) shows the summary report screen of the faculty and staff records saved in the database in addition to the total number of records belonging to the selected academic rank**.** The user is able to browse through the stored records using the command bottoms in addition to being able to view any information form file or CV file belonging to any record by activating the icon shown on the left of each record.

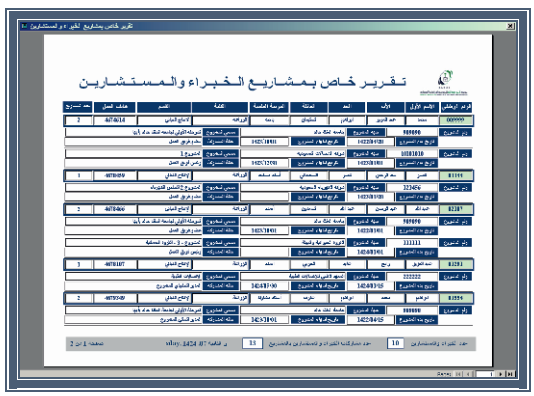


Figure (17) shows the first projects report screen which each faculty participated in, in addition to the total number of participants and total number of participations.

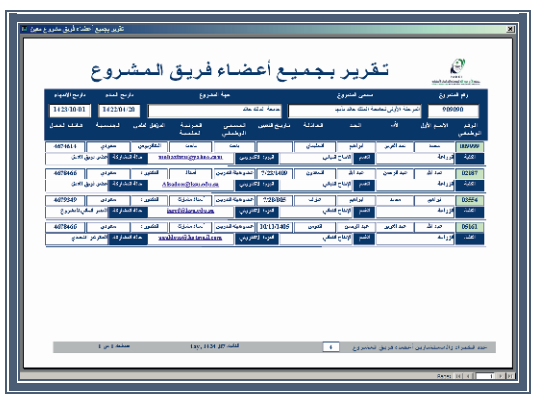


Figure (18) shows the main project information and the participants information report of project selected**.**

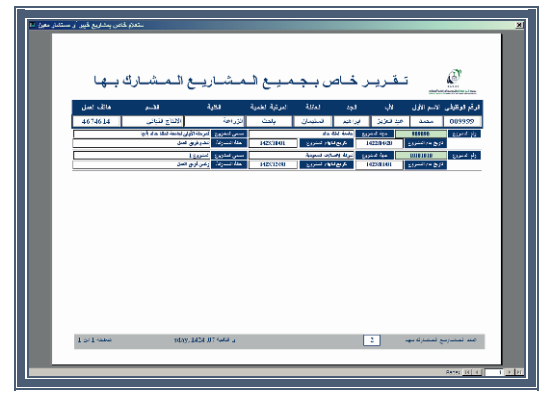


Figure (19) shows the report of the selected faculty information and all the projects participated in information.



Figure (20) shows the date period selection screen displayed prior to displaying a report of all projects initiated during the specified period.

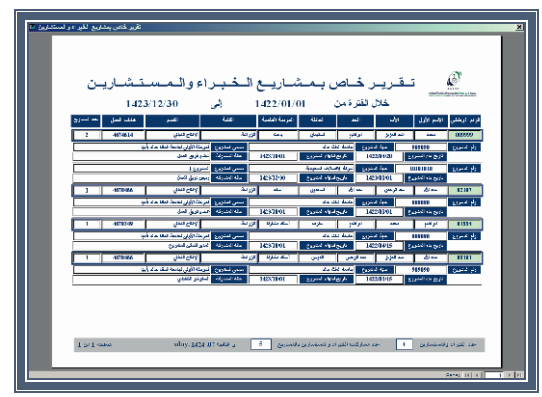


Figure (21) shows a report of the projects information initiated during the time period selected in **Figure (20).**

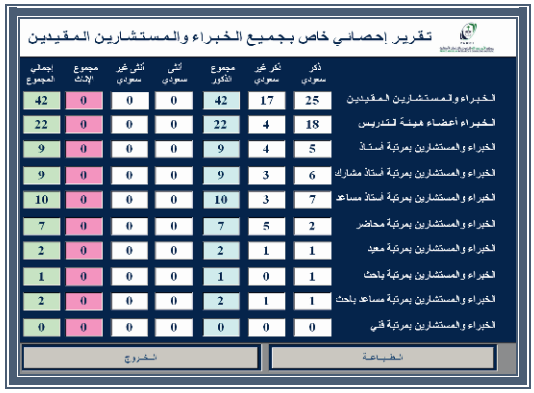


Figure (22) shows the statistical report of the faculty and staff records stored distributed by sex, nationality, and academic rank.



Figure (23) shows the keywords selections screen which is displayed prior to the specialization search report.

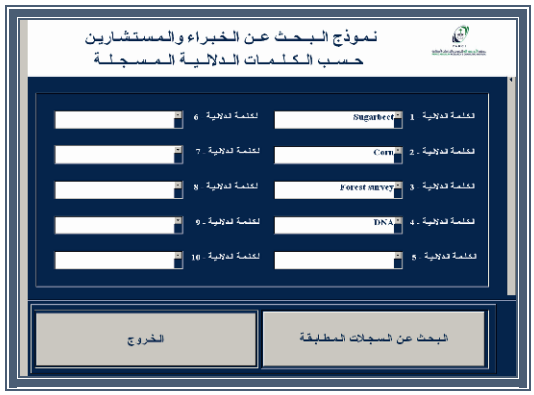


Figure (24) shows the keywords selections screen which is displayed prior to the specialization search report. Search would be done based on any of the specified keywords in the keywords fields.



Figure (25) shows the detailed report screen displaying all faculty information specialized in any related area according to the keyword(s) specified in **Figure (24)**, in addition to displaying the total number of stored records. The user may browse through these records by using the command bottoms shown at the lower section of this screen.



Figure (26) shows the manual search form screen where the user may generate an information report of all stored faculty and staff based on any of the values specified in the fields of this search form.



Figure (27) shows the detailed information report of all stored faculty and staff based on any of the values specified in the fields of the search form in **Figure (26).**



Figure (28) shows the manual search form screen where the user may generate an information report of all stored faculty and staff based on all of the values specified in the fields of this search form.



Figure (29) shows the detailed information report of all stored faculty and staff based on all of the values specified in the fields of the search form in **Figure (28)**.

Conclusion and Summary

Our goal in this paper was to show how we could solve a problem of selecting projects team members by implementing a relatively small database application which we could use to store the information of thousands of candidates (according to the official designed information form for all KSU Faculty and Staff) as well as storing images of that information form and images of their CV's to be reviewed on line when needed and obtain a fair selection group based on educational experiences participation in related projects. Practically, the process of selecting team members effort and time was reduced tremendously from a one week time to a one-hour time which added a major efficiency credit to the role of KAI-RCS and it's "automation of all tasks" trend.

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mmeybodi@aut.ac.ir

Automating The Work at KAI-RCS: A Case Study on Using Imaging Databases to Follow-Up Projects

Mohammad AbdulRahman ALGhalayini [1] and Mohammad ALIssan ALGhamdi [2]

[1]Director, Computer and Information Unit, Vice Rectorate for Branches
King Saud University, Riyadh, Saudi Arabia
[2]Dean, King Abdullah Institute for Research and Consulting Studies
King Saud University, Riyadh, Saudi Arabia

Abstract

Today, many institutions and organizations are facing serious problem due to the tremendously increasing size of documents, and this problem is further triggering the storage and retrieval problems due to the continuously growing space and efficiency requirements. This problem is becoming more complex with time and the increase in the size and number of documents in an organization. Therefore, there is a world wide growing demand to address this problem. This demand and challenge can be met by developing a process to enable specialized document imaging people to select the most suitable image type and scanning resolution to use when there is a need for storing documents images. This process, if applied, attempts to solve the problem of the image storage type and size to some extent. In this paper, we present a case study resembling an applied process to follow up the in charge projects in King Saud University King Abdullah Institute for Research and Consulting Studies by collecting project information and images of it's various documents and store them in an imaging database to make the retrieval of a specific project information and it's documents scanned images easier and faster; therefore, through this automation approach, we optimize the work process and maximize the efficiency of KAI-RCS tasks.

Introduction

KAI-RCS is King Abdullah Institute for Research and Consulting Studies. It is officially responsible for handling any researches, studies, or consultation projects required by King Saud University specialized members by various external governmental and private sector institutions; therefore following up these projects from their initial marketing stage till the end of the contract duration period.

As an official KSU institute, KAI-RCS is responsible for organizing and administering any consultation projects required by any outside institutions, KAI-RCS was having a considerable difficulty in following all projects information since the required information for projects, including status and installments due dates, for following up reasons were not directly accessible by the institute officials and it usually took a considerable time to get the required information from the employee in-charge of a certain project. This case was affecting the effectiveness of KAI-RCS's main duty.

A database system to include the information of all the projects handled and run by KAI-RCS was a must to make it easier and faster to refer and review any project information, status, and contract in addition to all in and out related project reports and documents[1].

Solution Steps

1 - A special form of four pages was properly designed and copied for projects information. Each form had a dedicated project number location on it's first page shown below in **Figure (1)**.
2 - A document scanner and a high specs. PC's were bought in preparation to be used when those forms and attached documents (contracts, faxes, project request letter) are ready at KAI-RCS.
3 - A database was designed, implemented, and tested to be used to store the forms information

[1] Project documents may include project contract, periodical reports, in and out letters and faxes, and project financial documents such as copies of team checks, bank statements, receipts, etc.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 351–359.
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mmeybodi@aut.ac.ir

as well as the scanned documents belonging to each starting project.

4 - By the time the database system was ready, a dedicated KAI-RCS employee started to fill the project forms and the project attached documents from all KAI-RCS projects including the finalized ones[2] according to a predefined time schedule.

5 - The data entry person who was previously trained on using the database system was ready to receive the forms with any accompanying documents and arranging them in folders categorized by the project requesting Institute for easier referencing.

6 - Each time the data entry employee used to come and scan the project form and the related project documents then store them in a folder on the local hard disk.

7 - This hard disk Institutional arrangement made it easy to quickly reference any stored document images and retrieve them when necessary.

8 - When the projects data was ready to be entered, all what the data entry person worried about is storing the information of the project form as text in the database system corresponding fields and storing the previously saved scanned image of the form in the corresponding OLE field, in addition to storing the contract file (which was scanned and stored previously as .max file or as a PDF file on the local hard disk) in the proper OLE field.

9 - After storing one full project form information and storing scanned documents belonging to that project (record), the project form is signed and dated by the data entry person, then stored back in the paper folder it belongs to. This step was necessary to easily figure out which forms where completely entered and which were not.

10 - Each week end, a complete copy of this database system was backed up on the central file server to be accessed by KAI-RCS authorized persons. In addition to saving a backup copy on a writable CD.



Figure (1) Shows side-1 of the designed information form.

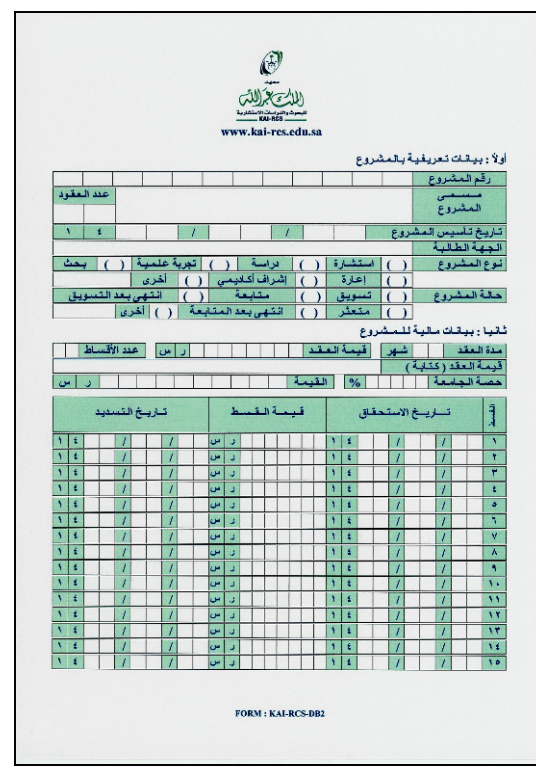


Figure (2) Shows side-2 of the designed information form.

[2] KAI-RCS started it's duties since the year 2000 and there was around 300 finalized projects when this database system was suggested. Collecting all those projects related information and documents was necessary for the annual statistical and financial reporting.

mmeybodi@aut.ac.ir

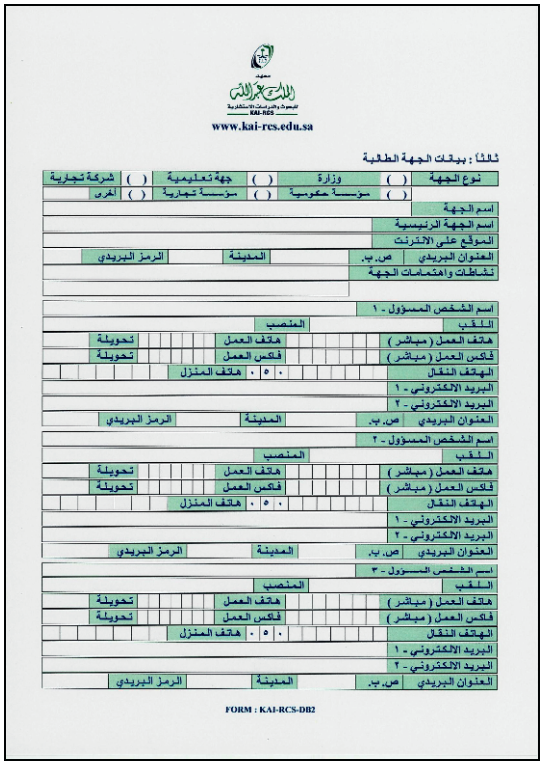


Figure (3) Shows side-3 of the designed information form.



Figure (4) Shows side-4 of the designed information form.

Special Notes about KAI-RCS Imaging Databases System to Follow-Up Projects

1 - This system was designed using MS-ACCESS RDBMS which is one of the MS-OFFICE 2003 applications.
2 - It was taken into consideration making this system a very user friendly and totally in Arabic language and easy to use as much as possible.
3 - All KAI-RCS PC's were updated to have 1024 MB of RAM at least and 128 MB display memory to access the system conveniently.
4 - All KAI-RCS PC's were connected through network to being able to connect to the dedicated central file server (KAI-RCS_SERVER) with a special user name and password for all authorized KAI-RCS employees.
5 - The system is accessible through a predefined password for security reasons.
6 - It is possible to print any page or pages of the project documents stored in database system on the central color laser printer, which is directly connected to the server.

Contents and Data Security

Since the KAI-RCS Projects Management database system may contain some private information which could be confidential, it was necessary to the KAI-RCS member including the data entry employee, to keep a special system password to use it to access the system whether from his own pc in the office or from connecting to the server from outside KSU campus.

And even though the server could be seen to others on KSU network but it was not accessible to any unauthorized person; therefore, the system was also not accessible to any unauthorized person.

One more thing regarding data security is the issue of weekly backup of the whole database system including the stored documents images on the server hard disk and on a removable writable CD.

HARDWARE USED

1 - PC with the following specifications:
2.8 Mhz Intel processor
1024 MB DDR RAM
80 GB WD Hard Disk
128 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor
2 - Image scanner with the following specifications:
40-60 pages per minute
Simplex / duplex

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Black and white and color scanning

3 – Central file server with the following specifications:
2.8 Mhz Intel processor
1024 MB DDR RAM
80 GB WD Hard Disk
128 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor

Software Used

Windows XP on data entry PC
Windows 2000 server on the file server
PaperPort 9.0 professional version for scanning images on the data entry PC

Time Consumed

As an automation project, there was a dedicated and limited time to finalize the project. The central database containing the images of the filled information forms and the stored documents images were ready to service KAI-RCS users after the first week of data entry phase (phase 5). The task of filling up the projects information each on a separate form was assigned to a couple of KAI-RCS employees. This process was performed simultaneously with the process of designing, implementing, and testing the required imaging database system. The following table shows the time consumed to finalize such an automation project.

No.	Details	Time consumed
1	Designing the form	2 week
2	Buying and setting up the hardware.	2 weeks
3	Filling up the projects data each in a separate form.	5 completed forms per day
4	Database system design and implementation and testing.	8 weeks (simultaneous with phase 3)
5	Data entry	5 complete records per day

Table (1) shows the time consumed for each process of the specified project

Screen Photos of the KAI-RCS Projects Management Imaging Database System



Figure (5) shows the main data entry form after passing through the authorization screen. The green field indicates the primary field[3]. The user may use the command keys on the bottom of the form to manipulate the data or/and add new records. In addition to the search keys to search through the previously stored projects records.

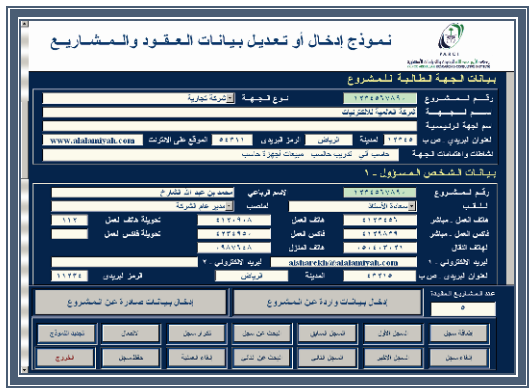


Figure (6) shows the first lower part of the main data entry form to show the data fields of the person in charge of the project from the outside party.

[3] Primary keys are used in databases tables to avoid duplication of records and to ensure data integrity and consistency.

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Figure (7) shows the second lower part of the main data entry form to show the data fields of the person in charge of the project from KSU side.



Figure (8) shows the third lower part of the main data entry form to show the data fields of the executive manager of the project from the from KSU side.



Figure (9) shows the fourth lower part of the main data entry form to show the data fields of person in charge of following up the project from the KAI-RCS side.



Figure (10) shows the actions screen to enable the data entry person to enter all the details related to the in coming documents belonging to this project.

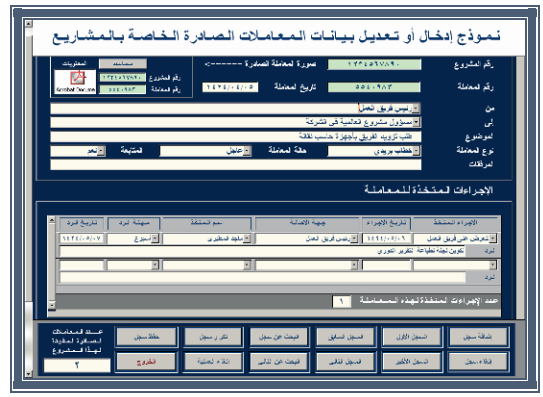


Figure (11) shows the actions screen to enable the data entry person to enter all the details related to the out going documents belonging to this project.



Figure (12) shows the built-in search dialog box to allow the user to search for existing records according to the criteria specified in “Find What” search field.

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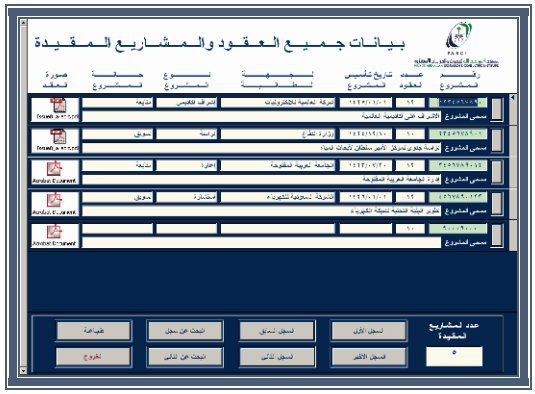


Figure (13) shows the all saved projects report displayed in addition to the total number of them. The project contract file is shown next to each project record as a PDF file.



Figure (14) shows the details of the selected project with it's unique number displayed when the user presses on the small button on the right side of the project record in **Figure (13).**



Figure (15) shows the resulted report belonging to the project type selected in addition to the total number of projects shown at the lower part of this screen.



Figure (16) shows the resulted report belonging to the requiring institution (the outside party) selected in addition to the total number of projects shown at the lower part of this screen.

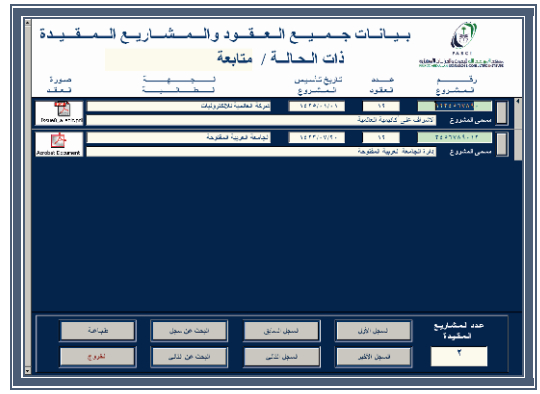


Figure (17) shows the resulted report belonging to the project status selected in addition to the total number of projects shown at the lower part of this screen.



Figure (18) shows the project initialization period selection screen prior to displaying a filtered report of all the projects of the selected initialization period.



Figure (19) shows the resulted report initialized during the specified period selected in **Figure (18)** in addition to the total number of projects shown at the lower part of this screen.



Figure (20) shows the resulted report belonging to the type of the project requiring institution selected in addition to the total number of projects shown at the lower part of this screen.



Figure (21) shows the details screen displaying all the information needed regarding the selected project. The user can browse through by moving vertically the vertical bar on the left side of the screen.



Figure (22) shows the project financial reports main selection menu.

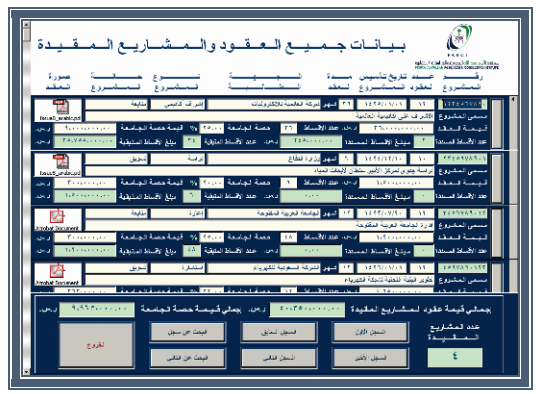


Figure (23) shows the financial report of all stored projects in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

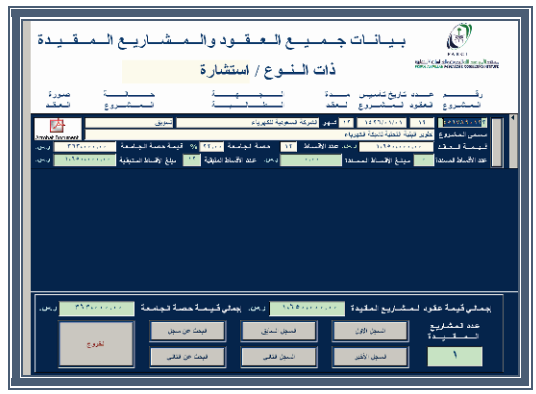


Figure (24) shows the financial report of all stored projects belonging to the type selected**,** in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by

pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

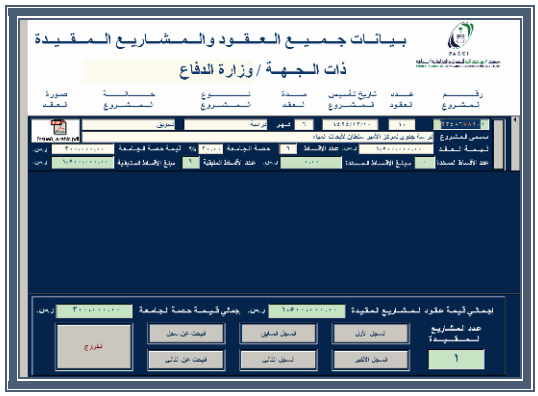


Figure (25) shows the financial report of all stored projects belonging to the requiring institution (the outside party) selected, in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

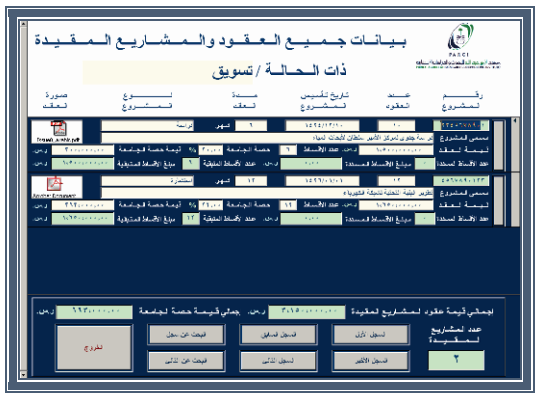


Figure (26) shows the financial report of all stored projects belonging to the status selected, in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

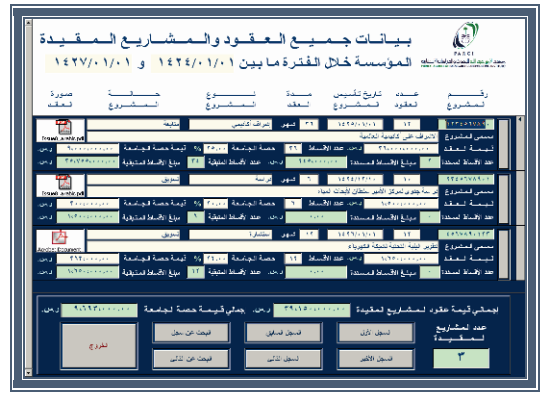


Figure (27) shows the financial report of all stored projects belonging to the initialization period selected, in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

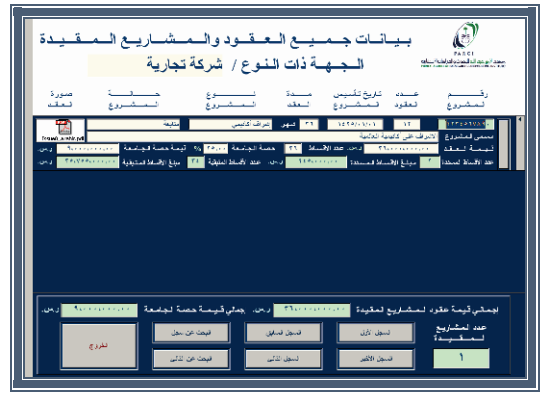


Figure (28) shows the financial report of all stored projects belonging to the requiring institution (the outside party) selected, in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

mmeybodi@aut.ac.ir

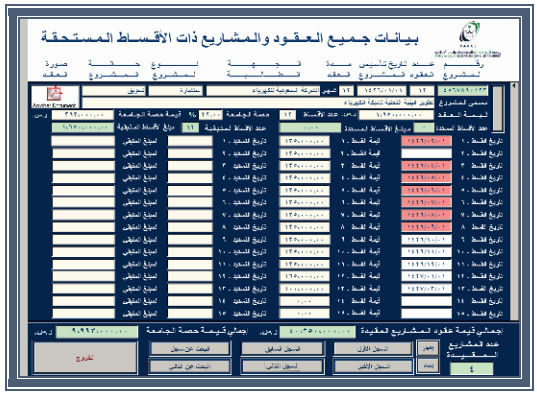


Figure (29) shows the financial report of all the projects that have installments over due (appearing in red color) to enable the employee in charge of following up to easily view the details of the installments due, in addition to the contract image(s) as an object on the left side of each project record. The user may display a detailed information screen of any project by pressing on the small button shown on the right of each displayed project record. Some financial information is displayed for each project and for all stored projects as well as the total number of projects on the bottom of this report.

Conclusion and Summary

Our goal in this paper was to show how we could solve a problem of managing and following up the ongoing projects by implementing a database application which we could use to store the information of those projects (according to the official designed project information form) as well as storing images of projects information forms and images of their related documents such as contracts, reports, receipts, etc. to be reviewed on line when needed and follow up each project accurately to guarantee detection of any failures that could occur in the progress of the project or the delays of the scheduled installments. Practically, the process of automating following up KAI-RCS projects and managing them by storing all of their information in a database system, reduced the effort and time previously consumed tremendously which added a major efficiency credit to the role of KAI-RCS and it's "automation of all tasks" trend.

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15 - "Read and Display an Image" available at : http://www.mathworks.com/access/helpdesk/help/toolbox/images/getting8.html

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mmeybodi@aut.ac.ir

Automating The Work at KAI-RCS: A Case Study on Using an Imaging Database to Administer and Manage The International Competition for King Khaled University Campus Architectural Design

Mohammad AbdulRahman ALGhalayini [1] and Mohammad ALIssan ALGhamdi [2]

[1]Director, Computer and Information Unit, Vice Rectorate for Branches
King Saud University, Riyadh, Saudi Arabia
[2]Dean, King Abdullah Institute for Research and Consulting Studies
King Saud University, Riyadh, Saudi Arabia

Abstract

Today, many institutions and organizations are facing serious problem due to the tremendously increasing size of documents, and this problem is further triggering the storage and retrieval problems due to the continuously growing space and efficiency requirements. This problem is becoming more complex with time and the increase in the size and number of documents in an organization. Therefore, there is a growing demand to address this problem. This demand and challenge can be met by developing a process to enable specialized document imaging people to select the most suitable image type and scanning resolution to use when there is a need for storing documents images. This process, if applied, attempts to solve the problem of the image storage type and size to some extent. In this paper, we present a case study resembling an applied process to accurately administer and mange The International Competition for King Khaled University Campus Architectural Design by King Abdullah Institute for Research and Consulting Studies through collecting all the competing firms information and paper material and store them in an imaging database to make the retrieval of information and the material scanned images easier and faster; therefore, we optimize the work process and maximize the efficiency of KAI-RCS tasks.

Problem Definition

KAI-RCS is King Abdullah Institute for Research and Consulting Studies. It is officially responsible for handling any researches, studies, or consultation projects required by King Saud University specialized members by various external governmental and private sector institutions; therefore, following up these projects from their initial marketing stage till the end of the contract duration period.

As an official KSU institute, KAI-RCS was responsible for organizing and administering an international competition for King Khaled[1] University campus architectural design. KAI-RCS was having a considerable difficulty in following up the competing firms information and their material and the incoming and outgoing material[2] flowing. This case was affecting the effectiveness of KAI-RCS's main duty since a close and accurate following and administering of this competition was very necessary for it's success.

A database system to include the information of the competing firms, in addition to information and viewable images of the incoming and the outgoing material, was a must to make it easier and faster to refer to any registered firm and competition member and review their material.

[1] King Khaled University is one of the governmental universities in the Kingdom Of Saudi Arabia located in Abha city in the Southern part of the kingdom.
[2] The in and out material contain faxes, letters, reports, photos, etc.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 360–365.
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mmeybodi@aut.ac.ir

Solution Steps

1 - A participation of firm Information form of two pages was properly designed and sent to be filled by all concerned architectural or consulting firms known world wide by dedicated KAI-RCS employee.
2 - A document scanner and a high specs PC were bought in preparation to be used when those forms and attached documents start to arrive back at KAI-RCS.
3 - A database was designed, implemented, and tested to be used to store the forms information as well as the scanned documents belonging to each competing firm.
4 - By the time the database system was ready, a dedicated KAI-RCS employee started to collect the forms and the attached documents from all competing firms according to a predefined time schedule.
5 - The data entry person who was previously trained on using the database system was ready to receive the forms with any accompanying documents and arranging them in folders categorized by colleges and departments for easier referencing.
6 - Each time the data entry employee used to come and scan the form and the profile of the competing firm then store the form in a folder and store the profile in another folder on the local hard disk. Both of those folders where stored in a parent folder having the name of the competing firm.
7 - This hard disk arrangement made it easy to quickly reference any stored document images and retrieve them when necessary.
8 - When the competing firm data was ready to be entered from the predefined Information form, all what the data entry person worried about is storing the information of the form as text in the database system corresponding fields and storing the previously saved scanned image of the form in the OLE field in addition to storing the profile file (which was scanned and stored previously as .max file or as a PDF file on the local hard disk) in the proper OLE field.
9 - After storing one full form information and storing scanned documents belonging to that record, the form is signed and dated by the data entry person, then stored back in the paper folder it belongs to. This step was necessary to easily figure out which forms where completely entered and which were not.
10 - Each week end, a complete copy of this database system was backed up on the central file server to be accessed by KAI-RCS authorized persons. In addition to saving a backup copy on a writable CD.

Special Notes about The International Competition for King Khaled University Campus Architectural Design Database System

1 - This system was designed using MS-ACCESS RDBMS which is one of the MS-OFFICE applications.
2 - It was taken into consideration making this system a very user friendly and easy to use as much as possible.
3 - All KAI-RCS PC's were updated to have 1024 MB of RAM at least and 128 MB display memory to access the system conveniently.
4 - All KAI-RCS PC's were connected through network to being able to connect to the dedicated central file server (KAI-RCS_SERVER) with a special user name and password for all authorized KAI-RCS employees.
5 - The system is accessible through a password for security reasons.
6 - It is possible to print any page or pages of the documents stored in database system on the central color laser printer, which is directly connected to the server.

Contents and Data Security

Since the KAI-RCS system may contain some private information which could be confidential, it was necessary to the KAI-RCS member including the data entry employee, to keep a special system password to use it to access the system whether from his own pc in the office or from connecting to the server from outside KSU campus.
And even though the server could be seen to others on KSU network but it was not accessible to any unauthorized person; therefore, the system was also not accessible to any unauthorized person.

One more thing regarding data security is the issue of weekly backup of the whole database system including the stored documents images on the server hard disk and on a removable writable CD.

Hardware Used

1 - PC with the following specifications:
2.4 Mhz Intel processor
1024 MB DDR RAM
80 GB WD Hard Disk
128 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor

mmeybodi@aut.ac.ir

2 - Image scanner with the following specifications:
40-60 pages per minute
Simplex / duplex
Black and white and color scanning
3 - Central file server with the following specifications:
2.4 Mhz Intel processor
1024 MB DDR RAM
70 GB WD SCSI Hard Disk
64 MB ATI display adaptor
10/100 3com network adaptor
40 X CD writer
17 inch display monitor

Software Used

Windows XP on data entry PC
Windows 2000 server on the file server
PaperPort 9.0 professional version for scanning images on the data entry.

Time Consumed

As an automation project, there was a dedicated and limited time to finalize the project. The central database containing the images of the filled information forms and the stored documents images were ready to service KAI-RCS users after the first week of data entry phase (phase 5). The task of filling up the projects information each on a separate form was assigned to a couple of KAI-RCS employees. This process was performed simultaneously with the process of designing, implementing, and testing the required imaging database system. The following table shows the time consumed to finalize such an automation project.

No	Details	Time consumed
1	Designing the form	1 week
2	Distributing the form to 80 competing firms.	1 weeks
3	Buying and setting up the hardware.	2 weeks
4	Database system design and implementation and testing.	6 weeks (simultaneous with phases 2 and 3)
5	Data entry	15 – 20 complete records per day

Table (1) shows the time consumed for each process of the specified project

Screen Photos of The International Competition for King Khaled University Campus Architectural Design Database System

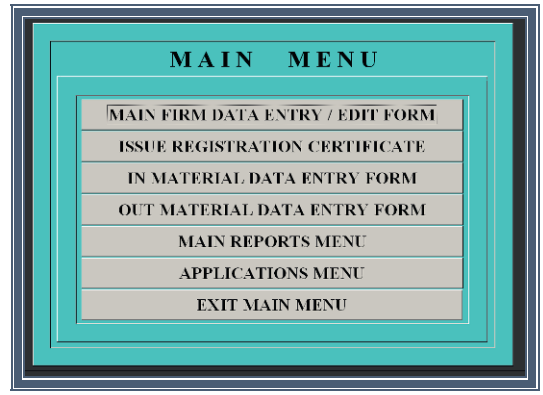


Figure (1) shows the main selections menu screen which is displayed when the user passes the authorization password.

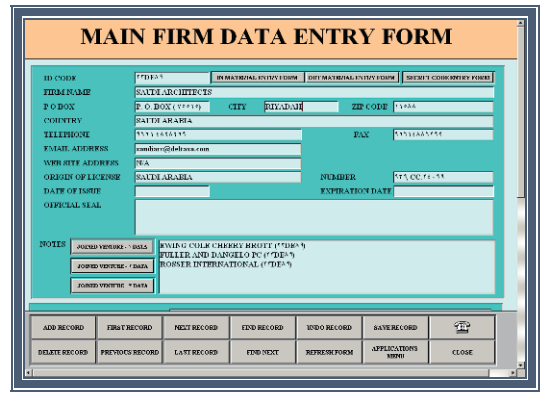


Figure (2) shows the main data entry form after passing through the authorization screen. The ID code field indicates the primary field[3]. The user may use the command keys on the bottom of the form to manipulate the data or/and add new records. In addition to the in-coming material and out-going material keys to store any In-coming and out-going material belonging to the current record.

[3] Primary keys are used in databases tables to avoid duplication of records and to ensure data integrity and consistency.

mmeybodi@aut.ac.ir

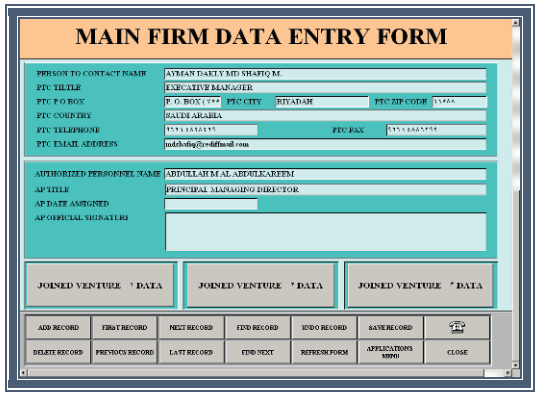


Figure (3) shows the form lower part of the main data entry form after passing through the authorization screen. In addition to the joined venture data entry forms opening keys which are displayed at the bottom of this screen.

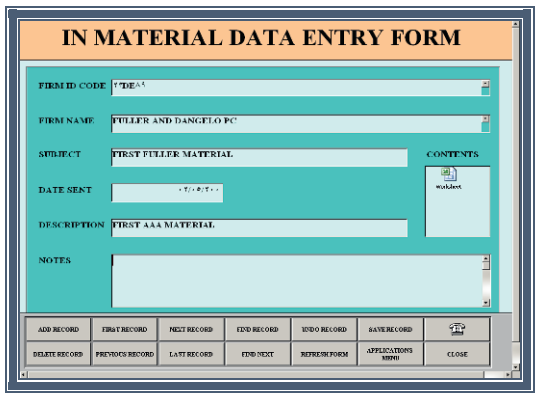


Figure (4) shows the ability to embed or link the OLE object which is a scanned image of the in or out material, here the inserted object was chosen to be displayed as MS-EXCELL icon in the field of this data entry form.

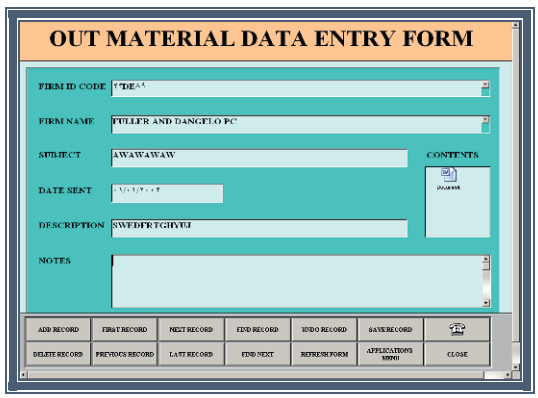


Figure (5) shows the ability to embed or link the OLE object which is a scanned image of the in or out material, here the inserted object was chosen to be displayed as MS-WORD icon in the field of this data entry form

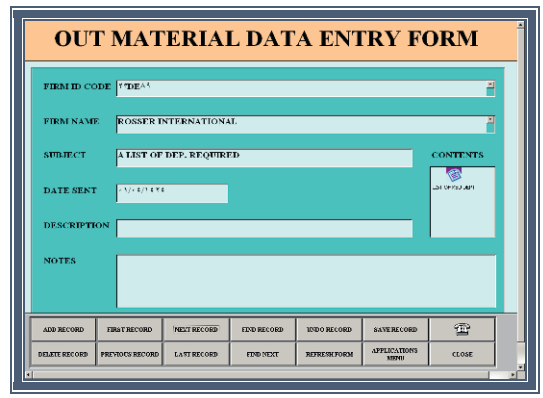


Figure (6) shows the ability to embed or link the OLE object which is a scanned image of the in or out material, here the inserted object was chosen to be displayed as a PaperPort[4] icon in the field of this data entry form.

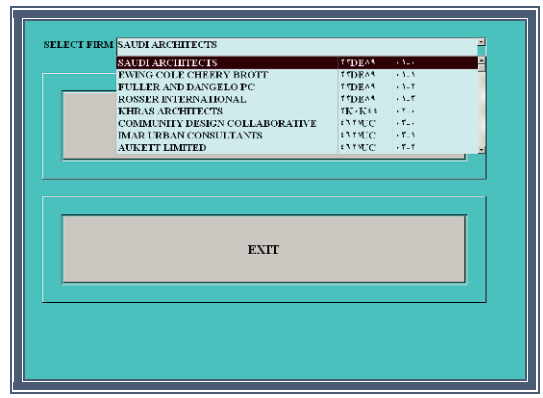


Figure (7) shows the ability to select one of the displayed values in the combo box to be stored in the firm selection field by pressing on the field down arrow.

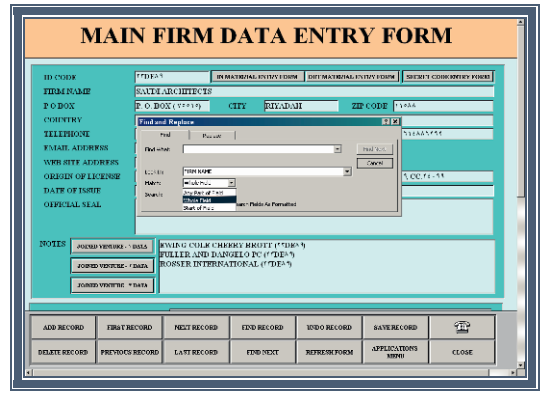


Figure (8) shows the built-in search options for the specified value as entered which is

[4] PaperPort is a trade name of ScanSoft Inc.

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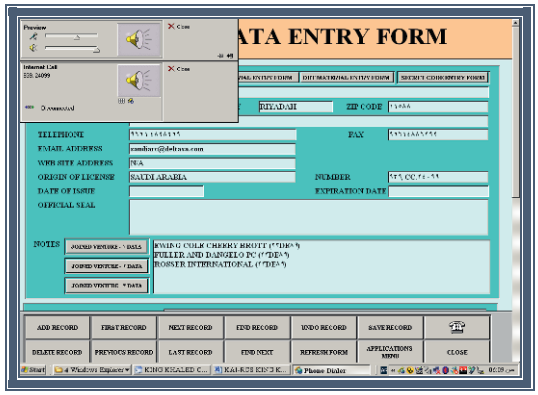


Figure (9) shows the Windows AutoDialer entry field when a dialing a stored phone number is requested.

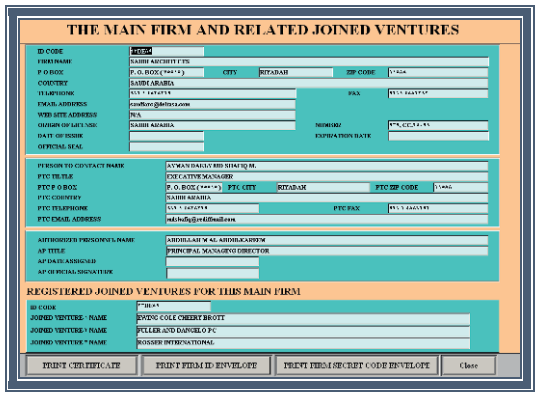


Figure (10) shows the form for entering the information of the firm joined ventures. The user may print a built-in certificate for this joined venture in addition to printing it's name and address on an envelop by using the command keys at the bottom on this sub form.



Figure (11) shows the main reports menu selection menu screen.

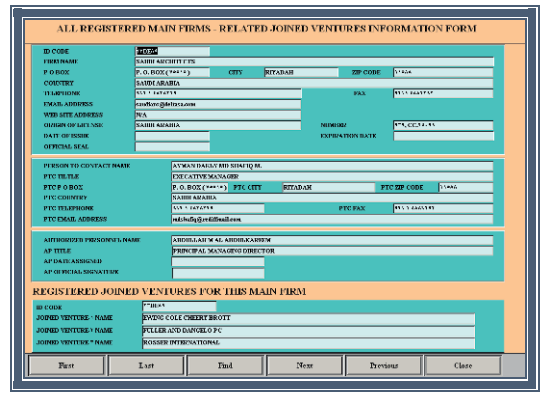


Figure (12) shows a report displaying all registered firms information screen which is option 1 of the main reports menu shown in **Figure (11).**

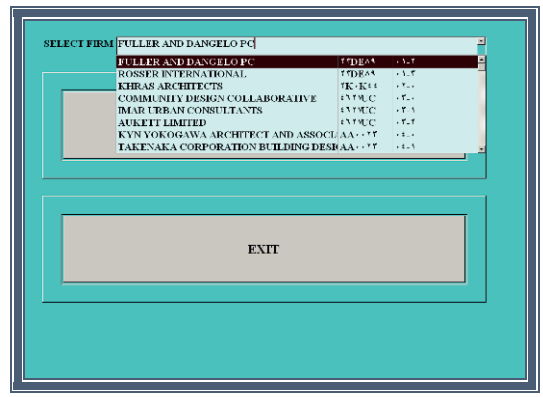


Figure (13) shows selecting the firm combo box. This screen is displayed prior to displaying all the in material report (report 3 in **Figure (11))** for the selected firm in this screen.

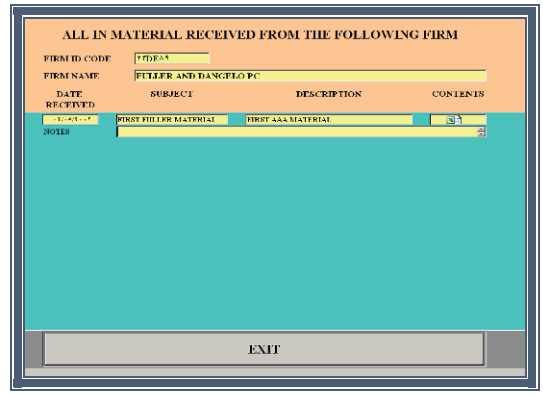


Figure (14) shows a report of all records for all the in material stored information screen for the firm selected in **Figure (13).**

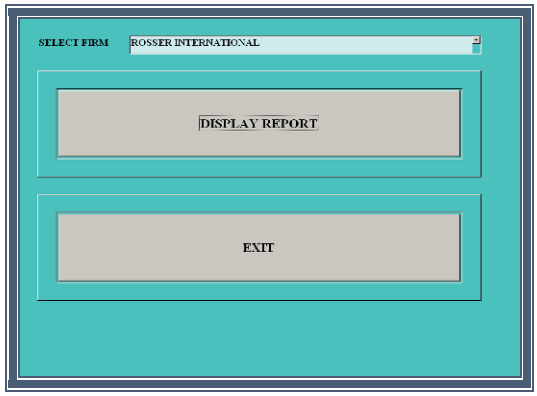


Figure (15) shows selecting the firm combo box. This screen is displayed prior to displaying all the out material report (report 4 in **Figure (11))** for the selected firm in this screen.

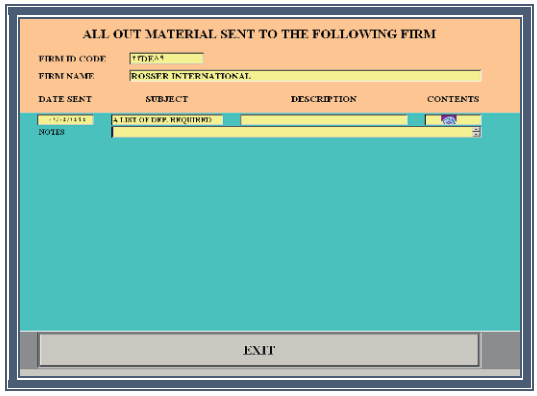


Figure (16) shows a report of all records for all the out material stored information screen for the firm selected in **Figure (15).**

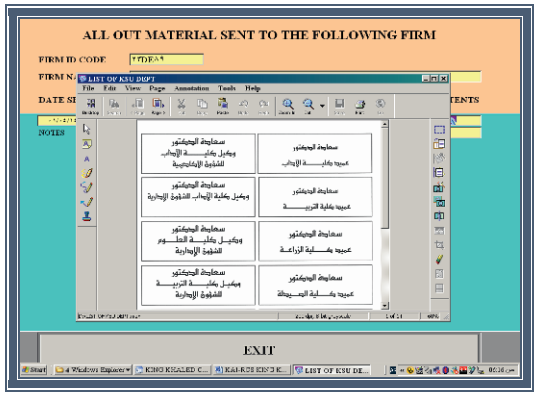


Figure (17) shows the view of a stored object (14 pages are stored as one OLE object). Here PaperPort application is activated after pressing on the object icon stored in the record displayed OLE field.

Conclusion and Summary

Our goal in this paper was to show how we could solve a problem of administering an international competition in an architectural design by managing and following up information of the participating firms and all the in-coming and outgoing materials belonging to those firms such as reports, photos, faxes, WORD files, EXCEL files, etc. by implementing a relatively small database application which we could use to store the information of tens of candidates according to the official designed information form, as well as storing scanned images of that information form to be reviewed on line when needed. Practically, the process of followed in storing all the related information and belonging material in an imaging database reduced the time and effort required to administer and followup such a task in addition to guaranteeing a high accuracy information level which added a major efficiency credit to the role of KAI-RCS and it's "automation of all tasks" trend.

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mmeybodi@aut.ac.ir

Response of First Active Teaching / Learning Course at Taibah University

Samir M. Shariff, M. Jawaid Siddiqui, Nazir A. Sheikh and Yasir M. Shariff,

Department of Mechanical and Electrical Engineering, College of Engineering, Taibah University, Al-Madinah Al-Munawwarah, P.O. Box 344, Kingdom of Saudi Arabia

Abstract-**The past decade has seen an explosion of interest among college faculty in the teaching methods variously grouped under the terms 'active learning' and 'cooperative learning'. However, even with this interest, there remains much misunderstanding of and mistrust of the pedagogical "movement" behind the words. The majority of all college faculty still teach their classes in the traditional lecture mode. Some of the criticism and hesitation seems to originate in the idea that techniques of active and cooperative learning are genuine alternatives to, rather than enhancements of, professors' lectures. In this paper, We are providing a response of active learning techniques which were obtained from students.**

I. Introduction

Teaching and learning methods are improving every day as we progress. Many universities are adopting these methods at different colleges throughout the world. Until today, engineering colleges have not fully acquired these methods even though the ideal teaching methods for engineers would be 'active learning' or 'cooperative learning'. In this paper, we are discussing a Method based on 'active learning' or 'cooperative learning' for the engineering instructors to adopt and practice while they teach their students. This paper, also describes the outcome of this approach in Taibah University.

II. Motivation

Today's teaching and learning methods have been improved tremendously. Throughout the universities around the world, the methods of teaching have been improved to a level that lets the student comprehend the basic material that the instructor wants to give plus more. These methods will not only improve the engineering student's, but it will enhance his/her capability of teamwork, leadership, design, open minded thoughts, open ended problems, the way of thinking, and more.

As with all novel methods, there are always obstacles at the beginning. Overcoming these obstacles, will take a lot of time and courage before changing them. Specially for engineering classes; where professors are used to teach with the old classical methods of writing and drawing on the blackboard as if they are talking to the blackboard and not caring about the students comprehension [1,2,3].

Some of these obstacles are :

- Professors think that they will be not able to cover the required material on time within the class period
- The professor thinks that his method is great and that he/she is doing just fine
- Needed resources are not available
- The professor think that he might not be able to control the class
- The student might not accept this style of teaching.

True, all the above mentioned items are real and valid causes to preventing this method from embarking at the engineering institutions. But if there is a will, there is a way. Thus, if we study each and every one of these obstacles, we may reach to a way to invert them into advantages rather than obstacles.

III. Corrective Thoughts

According to Dr. Covey's first of the Seven Habits of the highly qualified persons, is Paradigm Shift. Each one of us has a few paradigms that require an external force or an internal deep thought to change it. Therefore, if we consider the above obstacles as our current paradigms and that we have to shift our thoughts, and then we may find a way to overcoming them and take them to our advantage by converting them into advantages. [4]

Not being able to cover the required material on time within the class period: Many of the old fashion professors are concerned whether they will or will not finish the required material on time even with their style of teaching. This method, will increase the amount of time available during the class. The main reason on this is that the student will be coming to class

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 366–369.
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prepared in advance as will be stated on his/her assignment.

The professor thinks that his method is great and that he/she is doing just fine: Most of the professors believe that their style of teaching is the optimal. And since it has been done in the past with proven success, and student satisfactory results then why should they change. The reason for the change is that the industry always looks for more advanced and highly qualified students. This is achieved by plunging the student into the creative learning skills. In addition, this novel method increases the student comprehension drastically.

Needed resources are not available: This method of teaching requires only a PC, LCD Projector, movable chairs, and prepared students along with a motivated and active professor.

The professor might not be able to control the class: The beauty of this method is to have the class at a controllable chaos. This is similar to a nonlinear system where it is non uniform and yet it is going on a known track. Therefore the professor must possess high and active personality that he attracts the students to him/her just like a magnet attracting the iron to it [5].

The student might not accept this style of teaching: True, most students will resist this method as well. Specially since there will be a lot of reading assignments given to the student. As time passes, the student will notice that he is learning more and more importantly the student will feel that the knowledge and skills are being infused into his/her newly adapted style.

VI. PROPOSED METHOD

Knowledge, Skills and Techniques:
The major part of a course is the knowledge that consists of the textbook and those chapters that the instructor has selected to teach. Another main factor of knowledge that the instructors depend on are the notes prepared.

These are considered to many as the untouchable parts of the class. And we agree! The instructor's selection of the textbook and class notes are focal point of the course. Thus they will remain as they are with some changes in the methods of presenting them.

Students as with any class they attend have to read selected pages from the textbook as assigned by the instructor. Now, once the student comes to class prepared with the basic knowledge provided in the course textbook, he/she would be ready to indulge into the high speed knowledge provided by the instructor. This is done by the instructor presenting his/her notes to the students. Then the students have to participate by applying what they read in the textbook and what they learned from the class notes.

A real life situation is provided by the instructor on the blackboard. With the minimum givens and minimum amount of time; the students are suppose to discuss the problem among each other within their team and provide a list of brainstorming thoughts, then analyze the situation and finally provide the optimal solution.

Adding the Excitement to the Class:
To add excitement to the class, the instructor should take the class on a filed trip to a local facility that would related to the class material, or provide a video tape that would explain things in a more outgoing method. At sometimes the instructor might even take the class to participate at University on going project or maintenance work.

Putting things together:
By mid semester, the instructor starts giving biweekly projects to the students. These projects are open ended projects to test the team comprehension and capabilities on learning the required material. Each team member must be assigned an equal task to comprise into the total final product for the project. These design based projects must vary in its style and type.

V. CLASS TIME MANAGEMENT

In a three hour class, at least one hour per week and not exceeding an hour and a half should involve an active learning / teaching methods. How is that done?

On the first day, the instructor must explain briefly the methodology of active learning / teaching skill and putting the ground floor rules. That is after explaining the syllabus and contents of the course to be studied for the duration of the semester. In hand, the students must get prepared and ready once they meet again on the following week to participate and get an active role in teaching the class.

mmeybodi@aut.ac.ir

Thus, the first session of active learning / teaching must not begin until the last meeting of the second week of the semester. By then, the instructor would have given ample amount of information and knowledge to the students to initiate their learning experience. At the end of the semester, the student would have gained the knowledge, skills and confidents on mastering the given course.

in eight semesters. Besides this, the faculty quality, evaluation of students, faculty student ratio and, student counseling and advising have been discussed. Moreover infrastructural facilities like, computational/internet facility, library facility and laboratory facilities have been analysed. These all propositions are expected to reduce superfluous curriculum burdens on the students.

VI. RESPONSE FROM STUDENTS

For the first time the proposed method was imposed in the Taibah University and responses were obtained from the students, which are shown using bar chart diagrams. On y-axis students population is taken and on x-axis shows the choices. Following questions were asked.

Q1. Active Teaching was a great way of teaching.

Q2. You have participated in many active learning sessions, did this add information to your knowledge.

Q3. Classes were fun and very interesting.

Q4. Your reading assignment, home works, quizzes and project supported you to achieve the course objectives.

Q5. The course required less time and efforts to learn compared with other courses that you have.

Choices:

1 means strongly disagree
2 means disagree
3 means no opinion
4 means agree
5 means strongly agree

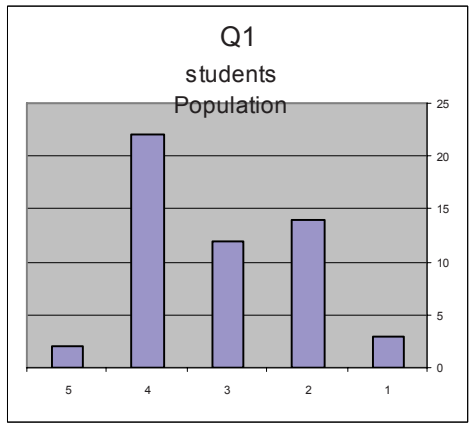


Fig. 1 Responses for question 1.

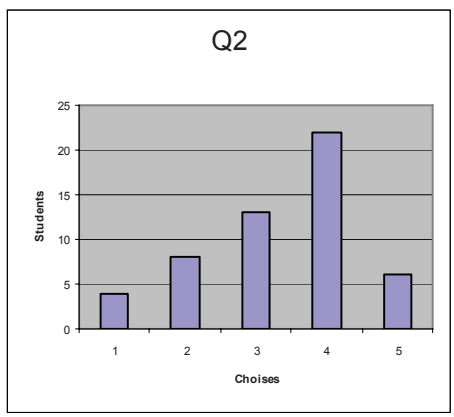


Fig. 2 Responses for question 2.

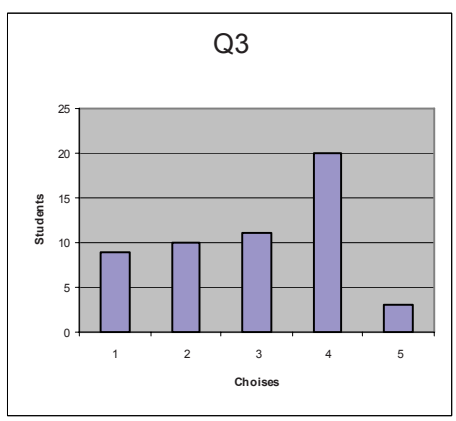


Fig. 3 Responses for question 3.

mmeybodi@aut.ac.ir

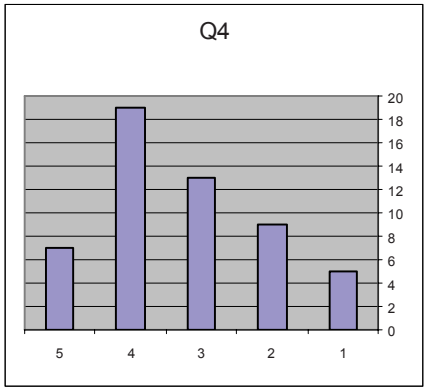


Fig. 4 Responses for question 4.

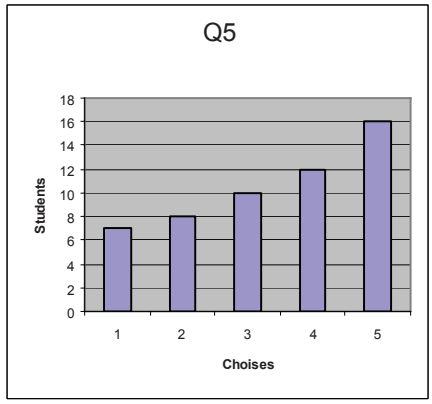


Fig. 5 Responses for question 5.

VII. Conclusion

After going through the above mentioned method of teaching in a class room and with all the excitement that may be included within the class period to enhance the engineering student's comprehension of the required knowledge and skills. We provide a list of some of the needed tips that may top our class participation and increase its motivation.

Students should be encouraged to participate in class by class discussion with the pre selected teams and within the entire class.

Learning skills must be taken by the student within the whole class as well.
Group discussion on assignments and solving them by answering pre selected questions.

Projects must be brain stormed and outlined at team participation.

Presenting each team's project by a team member that rotates at every project.

Lectures are still important, but must be administered at a separate session than that of active learning methods classes.

Evaluation methods must be different from the normal methods. It should be on student participation as well as the entire team participation. In addition, the evaluation must be done on carefully selected questions from these sessions.

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mmeybodi@aut.ac.ir

SimWiz – a Self-Learning Tool for Learning Discrete Event System Simulation

Moshe Cohen
Jerusalem College of Engineering, Israel
bani@jce.ac.il

Abstract - **A new tool for self-learning of simulation modeling is described that is especially utilizable in e-learning. The tool is a computer program called SimWiz (Simulation Wizard) that leads the user through well-defined steps. In each step the user is requested to respond to a simple request until the model is prepared. The final model can be quite complicated in spite the fact that each step in itself is simple. The model is translated to a commercial simulation program, Arena, and by examining it the student learns the use of building blocks of Arena.**

I. Introduction

E-learning or electronic learning tools are the generic term that refers to computer-based or internet-based techniques that reinforce the learning process. Reference [1] differentiates among four types of teaching modes depending on the percentage of on-line delivered portion in comparison with face-to-face instruction. It considers only students taking courses with more than 80% delivered online. Even so the number of students taking such courses has been growing in the past two years by approximately 20% and total enrollment was more than 3 millions in the fall of 2005. Thus, there is a sizable audience consuming e-learning.

There also exist a considerable number of tools for preparing courses for e-learning. However, they are generic tools that do not address specific problems of a given subject. The subject of the interest of this paper is discrete event system simulation appearing in the curriculum of every undergraduate industrial engineering department. The basic approach of this paper is the same as [2], albeit the present treatment differs due to a different set of criteria. The problem of interest is called by [2] simulation-focused learning that means teaching simulation model building methodology and techniques as opposed simulation-based learning that uses simulation to teach other subjects such as physics.

The teaching material presented in this paper is the program SimWiz [3] that facilitates self-study and therefore is a tool for distance education although it is not an e-learning component in the strict sense. It may be administered in simulation courses independent of the percentage given on-line.

Section II introduces simulation models for the sake of the general reader. In section III the incentive that led to the development of SimWiz is discussed. In order to explain the novelty of the proposed tool it will be compared by a representative of commercial simulation program, Arena [4] on a given simple program. Section IV describes the difficulties experienced by the novice in Arena in this model while section VI shows how the model is built by using SimWiz and section VII compares between the two. To understand this, the methodology of SimWiz is lined out in section V. Finally, section VIII summarizes how SimWiz serves the aim set in section III.

II. Simulation Models

Discrete event system simulations are useful in industrial engineering, service system planning, traffic control, communication engineering, processor design, and process flow control in general. Simulation is imitating reality such as traffic; work in a bank, in a port, in a warehouse etc. A very simple example for a situation that can be simulated by discrete event simulation is a machine that has three states: either working on some part, or idle or broken down. The transitions between states are instantaneous and occur at some discrete points of time. Such simulations are in general run on computers whose output can be yield conclusions about the simulated system. These simulations are extensively used for revealing flaws or allowing experimentation in the design of the system which can be tested 'on paper' before investing in the creation of an actual system, saving effort and cost.

The problems to be solved by simulation must be first formulated as simulation models that is also referred here as model building. Models are analogous to computer programs. One of the main obstacles of the novice who learns simulation is the model building that is not supported by the simulation software sufficiently for the inexperienced user. SimWiz tries to help the student through the model building phase.

III. Problems with Existing Software for Simulations

The incentive of developing SimWiz was to obtain the appropriate mix between the two basic goals of teaching simulations:

1. supplying the industry with graduates who are well skilled to build simulation models efficiently with aid of widespread commercial simulation programs
2. enrichment of students with theoretical aspects that are necessary to choose appropriate input, analysis of results and planning the simulation runs to arrive at correct conclusions.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 370–374.
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These goals are contradictory in the sense that each needs time and allocating more time to one goal means less time to the other. In conventional engineering education the skill-building activity has been either the underdog or left to self-study. This is the approach of most simulation text-books, see e.g. [5].

However, modeling of a given process as a discrete event simulation is far from trivial or self-evident. The modern simulation software has a lot of building blocks, each with its numerous attributes determining the behavior that should be appropriately connected. Moreover, there is a strong interdependence among the building blocks. Choice of the building blocks and the attributes and their interconnections comprises the simulation model. Unfortunately, neither the programs nor the text books specify any methodology for the modeling building process.

Simulation models are different from conventional computer programming from which they emerged in the early 60s. Considerable programming experience is not a preparation for model building. A practicing industrial engineer does not have to understand the inside working of the simulation software but definitely needs the skill and the theory to utilize it well. This is the basic difference of the tool of this paper and those in [2]. SimWiz does not pretend to teach how the simulation software works but tries to develop model building skills that can be transferred to commercial simulation software.

IV. Modeling wth Arena Software

In Israel the most widespread simulation software among industrial engineers is Rockwell's Arena [5]. It is also one of the most popular software in the US. Its operation is similar to most modern simulation programs such as Flexsim [6] or SimProcess [7], and model building is a similar process in most simulation software.

The model building activity will be illustrated below and shown in Fig 1 using the following problem.

> People arrive to a fast-food restaurant randomly at a rate of 2 per minute. 30% go to the sandwich counter, the remaining 70% order soup. A sandwich is prepared by a single worker in 30-90 seconds, most probably in 50 seconds. The soup is spooned by another worker in 20-40 seconds, most probably 25 seconds. All customers pay at a single cashier that takes 25 seconds with 5 seconds standard deviation, normally distributed. Eating takes on the average 15 minutes for sandwich and 12 for the soup. The deviation from the average is estimated as 4 minutes (for each customer).

Besides showing the Building blocks (altogether 60, arranged in three panels for discrete processes entitled "Basic Process", "Advanced Process" and "Advanced Transfer" shown in Fig 1.) and a graphic tool for connecting them (at the upper right corner of Fig. 1.) there is no indication or help for the user as how to construct the model. For the above problem the model is shown partially at the lower right part of Fig. 1. as interconnected shapes representing various actions or delays.

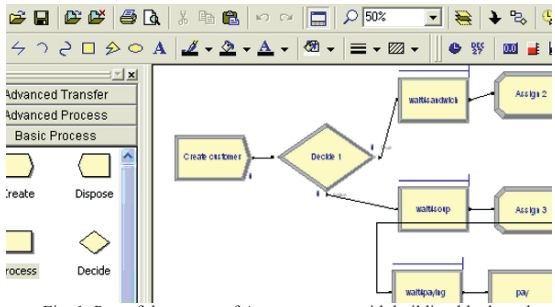


Fig. 1. Part of the screen of Arena program with building blocks at lower left part and the model in lower right part

Arena program is really very rich in its ability not only to build the model but also run the simulation with plentiful possibilities of animation, but the user must know how to use the building blocks correctly in order to model. Detailed helps are provided for each block, but learning from them is very time consuming.

V. Principles of SimWiz

The computer program SimWiz has four main components. The first is the knowledge acquisition of the system under consideration. It works like an expert system; it asks questions or requests information that can be easily supplied by user and builds the model accordingly. Each stage of the knowledge acquisition will termed *step* in the sequel. This is the component that is described here; this is the interface that makes easy for the inexperienced user to formulate the simulation model. The other components are for translating the model to commercial simulation software (Arena), running the simulation (in case that no commercial software is available) and producing documentation.

The novelty of the approach is that the steps are well-defined and fit *any* situation that can be simulated. The steps are as follows:

1. Determine all possible entity types relevant for the simulation.
2. Determine all possible delays that may occupy any of each of said entities. Delay in this sense is any place in the system that entities must wait for some reasons.
3. Determine all possible transitions of entities between the various delays denoted as directed arcs in a graph where the delays are the nodes.
4. Determine the cause for each of the delays, said reasons being chosen from the following list of possible reasons (in the sequel delays of reason a. will be called *process-type* and reasons b. through h. – *queue-type* delays):
    a. a process to end,
    b. a resource to become free,
    c. a condition to be satisfied,
    d. a transporter to become free,

mmeybodi@aut.ac.ir

e. a vacant place on a conveyor,
f. batching,
g. synchronizing,
h. nothing - waiting indefinitely to be stopped waiting by another entity,
i. nothing - waiting 0 time; this is an artificial or dummy delay that is handy to deal with many situations.

5. For all process-type delays, the duration of said processes and the necessary resources and quantities for completion of the processes, and disposition of resources on completion of a process.
6. For all process-type delays, data pertaining to said resources, consisting of costs, availability of resources and delays in which resources are seized, possible breakdowns, breakdown durations, and rules of governing the breakdowns.
7. For all entities, data pertaining to the entity type, including arrival pattern and delay to which entity arrives first, time of first arrival, holding costs, maximum arrivals, batch size, and representative icons for purposes of visualization and/or animation.
8. For each case in which more than one entity originating from different delays may enter a given delay, a rule regulating the choice of entity or combination of entities entering the given delay, in the case where one entity must be chosen to enter the delay said choice being either random, ordered, defined by a function, or based on queue length, and in the case where a combination of entities may enter a delay, whether said combination is permanent, temporary, or comprised of batching any or specific entities.
9. For each case where there exists a choice of subsequent delay upon completion of a given delay, rules regulating the choice of delay to take, said choice being based on entity type, predefined order, function evaluation, random choice, according to queue size if the destinations are queues, according to remaining capacities if the destination(s) are processes using resources, or indication that the entity is to be split and a copy sent to each possible subsequent delay.
10. For each case of waiting for a transporter to become free, information about the transporter such as possible routes, route lengths, speed(s), and carrying capacity.
11. For each case of waiting for a vacant place on a conveyor, information about the conveyor such as speed and carrying capacity.
12. Determine additional tasks not deduced from the above steps, including provision for input, creation of output, creation and separation of temporary batches, terminating the stay of entities in delays, freeing resources seized in other delays and assigning values to quantities or attributes, said tasks being executed either prior to entering or after leaving a delay.
13. For all queue-type delays, namely waiting for a resource to become free, a condition to be satisfied, a transporter to become free, a vacant place on a conveyor, batching, or synchronizing, determine queue data including how entities are ordered in the queue such as first in-first out and other disciplines, capacity, and further information in cases of conditions, batching, and synchronizing.
14. Define symbols representing attributes, constants, variables, functions, stochastic state variables, and/or Boolean or arithmetic expressions involving one or more of said symbols, wherein said variables may be scalars, vectors, or arrays, as well as starting values for constants and variables, allowing the simulation author to freely make use of said symbols in any of the preceding specifications.
15. Determine rules for assigning priority in cases that more than one entity may request a common resource.

The program SimWiz presents the user appropriate input prompts according to this order. For more advanced users it is possible to jump back and force among the steps. Moreover, it is possible to save the model at any stage of development and start from that point on at a later session. The model may be checked for errors and translated to Arena model, such as shown in Fig 1.

VI. Modeling with SimWiz

We shall describe now the model building phases in SimWiz with the above example problem. Portions of the windows of most of the steps are shown in Figs 2 through 14. Most of the windows shown in these figures are self-explanatory when the figures, their captions, the steps of the previous section are considered together in view of the example problem.

The steps provide either a list (for listing entity types, delays, resources or variables) or provide one or two lists for choosing an entry or a pair of entries. The choice may pop up a window where the details of the entry or the pair may be keyed in. In such cases only one of the pop-up windows is shown (see Figs 8, 10, 11 and 14).

It is fully appreciated that a novice cannot list all the delays or other elements correctly at the first time. For example, it may not be evident at the start that the dummy entity "entrance" (see Figs 3 and 5) is necessary. The first trial of modeling may lack a few essential parts. A correct model evolves during a number of reformulations very much like scientific article. Notwithstanding, the steps of the above methodology give a systematic way of developing the model that helps the user. Reviewing the model may indicate the necessary changes that necessitate adding entity types, delays, resources or variables. The model as shown in Figs 2 through 14 is the final model, after a few reformulations, for lack of

mmeybodi@aut.ac.ir

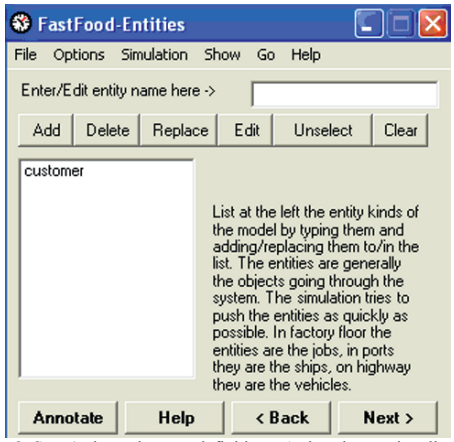


Fig. 2. Step 1: the entity type definitions. A short instruction directs the user what to do in the step. The names may be freely typed in.

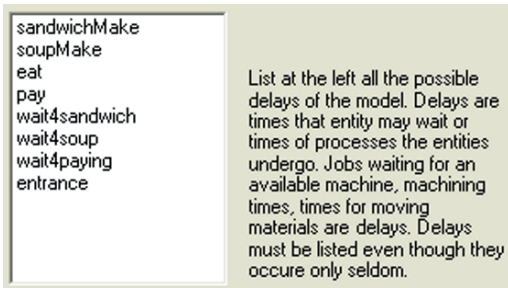


Fig. 3. Step 2: the delay definitions. Delay "entrance" is a dummy delay that is necessary to set different routes to the two types of customers.

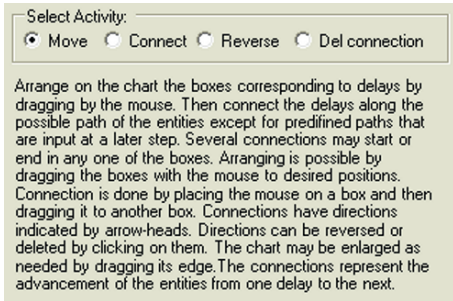


Fig. 4. Step 3: the transition definitions. The transitions are modeled by a directed graph on a different window that eventually looks as shown in Fig 5.

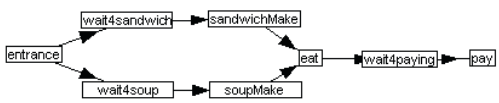


Fig. 5. The graph of the model showing the possible routes the entities may take.

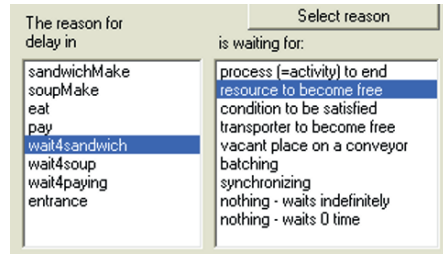


Fig. 6. Step 4: the reasons of delays

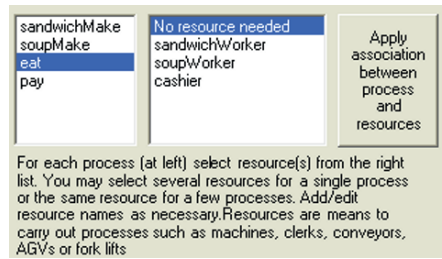


Fig. 7. Step 5: listing the needed resources that should serve process-type delays.

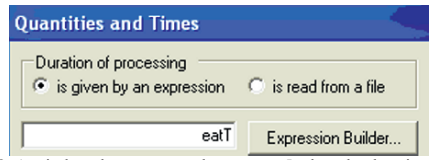


Fig. 8. A window that pops up when at step 5 when the duration of the process-type entities are defined. The expression "eatT" is to be defined at a later step.

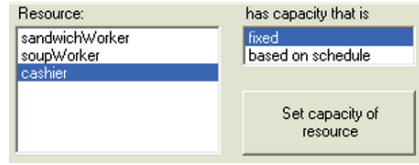


Fig. 9. Step 6: the features of resources



Fig. 10. The window that pops up in step 6 for defining the details of the resource

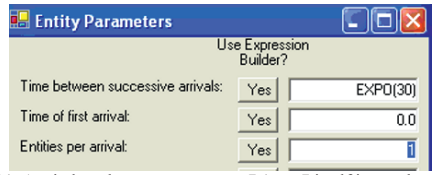


Fig. 11. A window that pops up at step 7 (step 7 itself is not shown) for defining data of entity types

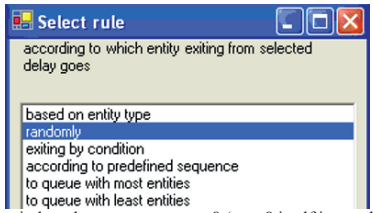


Fig. 12. A window that pops up at step 8 (step 8 itself is not shown) for choosing the rule of route selection. For the first three possibilities a further window pops up for data input.

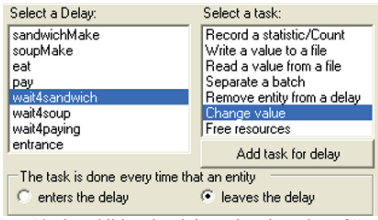


Fig. 13. Step 12: the additional task is setting the value of "eatT" that is different for the two types.

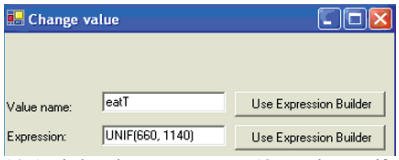


Fig. 14. A window that pops up at step 12 to assign a uniformly distributed random variable between 660 and 1140 seconds to "eatT".

space the intermediate (and incomplete) formulations are not shown.

Note that not all the steps and pop-ups are shown and not each step of the 15 steps of previous section is required for this model. From the input of step 4 it it is deduced that there is no need for steps 10 and 11 as no entity is waiting for transportation or conveying. Also, there is no need for step 15 because there is no resource serving two different process-type delays.

Variables and attributes can be freely used during the steps where appropriate. They should be defined only in step 14, including starting values for scalar variables and elements of arrays. Array elements may be functions or expressions. Expressions may be constructed by an expression builder that directs the user about all 49 possible inbuilt functions regarding correct spelling and arguments, all 6 inbuilt attributes of entities and all the symbols entered by the user previously. The functions EXPO(30) in Fig. 11 or UNIF(660,1140) of Fig 14 could have been written by the expression builder. If a detail may be a variable or attribute the expression builder can be activated by a button see e.g. Fig 8 and 14. The fact that there is no such button at definition of capacity in Fig 10 means that it must be a number, not a variable or attribute.

VII. Comparing SimWiz with Commercial Simulators

SimWiz also can run the model and even perform some simple animation; in this sense it is a stand-alone simulation program. However, this was not the main aim of its development. Its novelty and main use is to teach model building and the skills to use commercial simulation software such as Arena.

For this purpose it is possible to translate the model to Arena. The student can check now the Arena model and see how the model is formulated there and learn the ways how Arena treats the situation.

What is required for running the first simple simulations with SimWiz is only the meaning of entity, delay, resource, variable and attribute and expressing the possible routes of entities through the system as a directed graph. All these are quite natural concepts that can be taught less than one hour.

Even without such preparations SimWiz can be used as at each step there is an explanation on the window (see Figs 2 through 4). Online help provides more detailed explanation at each step. As opposed to this minimal preparation, learning Arena is quite lengthy as mentioned previously.

For teaching more involved models SimWiz is accompanied by a tutorial that shows through examples how to build the model and includes the main modeling techniques. The topics not covered in the tutorial are discussed in the appendix or help is provided.

VIII. Conclusions

SimWiz makes possible to learn model building by self-study. Therefore it frees time for the second goal of section III, so that more time can be devoted to enrichment of students with theoretical aspects. Teaching skills to operate commercial simulation programs, thus preparing the industrial engineering student for professional carrier, is achieved by observing how models are translated to Arena.

SimWiz can be used in face-to-face as well as in on-line delivered courses. In these cases it can be used in class assignments accompanied by questions that check whether the student understands not only the model building but also the details in a commercial simulation program's building blocks.

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mmeybodi@aut.ac.ir

Superfluous Curriculum Burdens on Mechanical Engineering Students, Causes and Remedies

Nazir A. Sheikh, Yasir M. Shariff, Samir M. Shariff and M. Jawaid Siddiqui

Department of Mechanical and Electrical Engineering, College of Engineering, Taibah University, Al-Madinah Al-Munawwarah, P.O. Box 344, Kingdom of Saudi Arabia

Abstract-**Conventional mechanical engineering curriculum practiced world wide, offers courses on manufacturing engineering, thermodynamics, heat transfer, industrial engineering, mechanisms, vibration and control, and mechanical design in single or multiple fashion. This scheme contains extra or repeated (superfluous) subjects and lack some fundamental courses. These superfluous courses need to be addressed for removal. The current engineering field expects the professional to excel beyond the boundaries of conventional curriculum. If the expected mechanical engineer is trained according to the expectations of the companies without making him to know all conventional trades, the curriculum burden can be reduced to a large extent. Different streams of specialties are to be created in the curriculum to satisfy the job market. A decision needs to be made whether some portion of the curriculum can be shifted to the companies to train the engineering bachelors according to their taste or such a burden be put on the student in the college. Strong intellectual, innovative and technical foundations need to be made of the engineering bachelors by addressing, curriculum, faculty, laboratories and computational facilities like issues in an optimised form.**

I. Introduction

It is well known that the scientific and technological developments continue rapidly and obsolescence occurs too quick in engineering products. Manufacturing and market paradigms change very fast. Super computers of yesterday became personal computers of today. The present engineering professional has to keep himself updated with the ongoing technological developments so is the case with the teachers, facilities and administration. In such circumstances superfluous things in any scenario need to be eliminated. Engineering curriculum is one of the key issues to be looked into for such unnecessary items. Any curriculum is prone to such bugs. Normally we pay more attention to redundant portions of a particular programme than core issues. This way we may produce a technician instead of an engineer out of a programme. Engineer is expected to develop what is not whereas a scientist discovers what is already present. Today's every step of effort will be checked whether the action is in the right direction or not, so that no superfluous steps remain in the process. Engineering professional is expected to be able to judge the challenges of the market and the society to provide the best design of a product in terms of cost and the quality. In the recent years world has seen change of scenarios in every walk of life. In education, industry, profession, defense, market and jobs, every where there are number of engineering problems which an engineer is expected to understand and solve. Many people have viewed curricula for feasibility and from compactness. Many of these issues have been discussed in Refs. [1-4]. Wachtel et.al Ref. [5] reports that students lose fundamentals in colleges which would enable them to adapt to future changes. Alice Agogino [6] while explaining the condition of engineers produced from the colleges says that the engineering bachelors are not capable of facing competitions in industries. Many papers have proposed and even implemented various types of curriculum reforms, with some promising results.

Conventional mechanical engineering curriculums offer six courses in every semester of a four years degree programme. These courses include three courses in manufacturing, five courses in thermodynamics/machines, three courses of industrial engineering, eight courses of mathematics and several other courses. These courses don't include any fundamental courses like Classical Mechanics and Thermodynamics, Electrodynamics, Vectors and Tensors, and Continuum Mechanics. This way the student undergoes through only numbers of courses but not through fundamental courses. The student does lot of labor work but does not attain intellectual capability. He is kept frustrate throughout the programme and does not enjoy learning and feels that the programme is a

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 375–380.
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mmeybodi@aut.ac.ir

burden. These issues need to be addressed thoroughly.

In the present study, a curriculum, rich in fundamental courses for mechanical engineering bachelor's degree has been proposed which incorporates the ABET (Accreditation board for Engineering and Technology) recommendations and is expectedly free from superfluous burdens on the students. Moreover student teacher ratio, text book teaching, type of laboratories and other reforms have been proposed.

II. Simple Curriculum Design

In order to address the removal of superfluous curriculum burden, one needs to refer to the objectives required in producing a mechanical engineering graduate. Following are the approximate objectives to be achieved out of a mechanical engineering programme:

1. Realisation of professional and ethical responsibility.
2. Communication skills.
3. Ability to exhibit team work culture.
4. Ability to identify, formulate, and solve engineering problems.
5. Acquired intellectual capacity to understand necessity of engineering solutions.
6. Ability to learn life long.
7. Ability to use the engineering knowledge for problem solving.
8. Ability to apply knowledge of mathematics, science, and engineering in engineering problems.
9. Ability to design and conduct experiments, as well as to analyse and interpret data.
10. Ability to design a system component which meets the requirements.

Our goal is to achieve above mentioned objectives without loading the students with the superfluous academic burden. To achieve the objective numbers one to seven, a course of engineering profession is needed at freshman level. This course must train the student in self regulation, communication skills, team work culture, problem understanding, problem modeling and problem solution. Though the student will achieve more knowledge to solve a problem in higher classes but he will bear in his mind throughout the higher classes the need of other tools required to solve a problem. This course may be of about **four credits**. The name of this course can be Engineering Profession and Ethics (currently engineering design). Objective number eight can be achieved through a scheme of freshman/sophomore courses with a 10+2 class back-ground as given in Tables I and II:

TABLE I

GENERAL REQUIREMENTS

Requirements	No. of Credits	Description
University	X	(Students are expected to know humanities courses from 10+2 level)
College	40	Basic Sciences (12)* & Math.(8) and General (20)
Department	56	Core (40), Specialty (16)
Total	96	

* Concentration of 12 Credits in Physics.

Objective numbers nine and ten can be achieved by offering single mechanical design course of **four credits** with a design project. Besides strengthening the aptitude to design, a scheme of courses as given in Tables III and IV is required.

Moreover to specialize in a particular mechanical stream, four electives (Table V and VII) can be opted (**4x4=16credits)**.

This way a curriculum of **ninety six** credits has been designed with a total number of courses equal to twenty four. Hence 3 courses can be offered per semester and in four years degree (eight semesters) can be easily completed with ease. The nomenclature used for the course codes is as, **GE** (general engineering), **PHYS** (physics), **MATH** (mathematics), **ME** (mechanical Engineering), **EE** (electrical engineering), **XE** (electrical or mechanical engineering), **GE xyz** (**x**-number of year, **y**-specialisation, **z**-fall or spring).

Twelve credits of course work has been offered per semester as shown in Table VI. Nominal number of credits have been offered per semester in order to master the subjects instead of learning the course superficially. It is our personal experience that students after B.S. degree don't know whether stress and strain values correspond to a point or a path. Same is problem with other fundamentals in electrodynamics, circuits, fluid mechanics, thermodynamics and

mmeybodi@aut.ac.ir

heat transfer. Reason behind this is that conventional curriculum offers lot of superfluous credits and waste time of the students. This leads to students knowing every thing superfluous and less fundamental. The curriculum proposed in this paper will surely produce a hard core mechanical engineer with solid foundations.

TABLE II

COLLEGE REQUIREMENTS (BASIC SCIENCES AND MATHEMATICS)

Course Title	Course No.	No. Credits			Pre-requisite
		Lt.	Lb.	Cr.	
Ordinary & Partial Dif. Eqs.	MATH 101	4	0	4	
Complex Variables, Probability & Statistics	MATH 102	4	0	4	
Vectors, tensors and solid geometry	PHYS 101	4	0	4	
Electro-dynamics and Circuit theory	PHYS 211	3	3	4	PHYS 101
Classical Mechanics and Thermo-dynamics	PHYS 102	4	0	4	
Total				**20**	

III. FACULTY REQUIREMENTS

Following points are to be borne in mind while selecting the faculty for teaching:

1. Reputation of the institution from which the teacher has qualified.
2. Communication skills.
3. Attitude and physical attributes
4. Field of specialisation
5. Number of publications in reputed journals.
6. Past experience and positions held.
7. Number of research projects completed.

TABLE III

COLLEGE REQUIREMENTS (GENERAL)

Course Title	Course No.	No. Credits			Pre-requisite
		Lt.	Lb.	Cr.	
Computer Applications in Engineering	GE 101	4	3	4	
Engineering Design	GE 102	4	3	4	
Engineering Mechanics (Statics and Dynamics)	GE 202	4	0	4	PHYS 101
Continuum Mechanics	GE 212	4	0	4	ENGL 103
Engineering Economics and Management	GE 402	4	0	4	
Total				**20**	

Faculty is important in an educational institution as heart works in body. If faculty is of high caliber, quality of students will be high. Dynamic and capable faculty brings up the institution reputation to the top international level. They build useful laboratories, bring research projects, produce bulk of quality research and attend thoroughly to the student component of the institution.

Student faculty ratio can vary from three to seven. Beyond this quality of students will be affected. More teachers can make the programme diversified. However teachers may be directed to follow quality text books. Help students to understand the fundamentals rather than concentrating on bulk. Teachers must not be of harsh attitude like failing full class in one go. They must give thought to the question papers before putting them into practice. They must realize that if the confidence of the students is destroyed by a hard question paper then he is not definitely doing a good job.

mmeybodi@aut.ac.ir

TABLE IV

DEPARTMENT REQUIREMENTS (CORE)

Course Title	Course No.	No. Credits			Pre-requisite
		Lt.	Lb.	Cr.	
Manufacturing and Eng. Graphics	ME 222	3	3	4	
Materials Science	ME 231	3	3	4	
Thermo-dynamics and Machines	ME 271	3	3	4	PHYS 102
Mechanics of Materials	ME 351	3	3	4	GE 202, GE 212
Mechanics of Machinery	ME 341	3	3	4	GE 202
Fluid Mechanics	ME 371	3	3	4	GE 212
Instrumentations & Power Plant Eng.	ME 421	4	3	4	
Mechanical Design	ME 352	3	3	4	ME 351
Professional Training in ME	ME 390	0	0	0	GE 102
Heat Transfer	ME 372	3	3	4	ME 271
Control and Vibrations	ME 342	3	3	4	MATH 101, GE 202
Total				**40**	

IV. STUDENT COUNSELING AND ADVISING

Students performance may be checked continuously and likewise ways may be sorted out as to how the student may perform better. His family problems may be looked into. Instead of penalizing students, their problems may be attended and solved. Of course there is no compromise with the discipline to be maintained in the institution but approach towards solving problems has to be positive.

TABLE V

SPECIALITY

Course Title	Course No.	No. of Credits			Pre-req.
		Lt.	Lb.	Cr.	
4 XE Adv. Eng. electives	XE 4XX	4	0	4	
Total				**16**	

* Specialization Program must be completed from a list of engineering electives.

V. LAB./LIBRARY/COMPUT. FACILITY/INTERNET

These are the four components of the institution infrastructure which make an academic and research environment. Laboratories in a particular field like mechanics of materials are to be so established so that consultancy projects can be worked out. We must provide full testing facilities to the outside companies so that institution and staff will make financial benefit. Research must be thoroughly connected with the facilities so that institution has not to pay additional funds for the research equipment and research component is not in any case paid less attention.

Libraries save enormous time for research and provide an academic backing to the student learning. Years of useless research can be avoided by going thoroughly in to the literature review. So libraries must be equipped with reputed journals and periodicals besides text books prescribed for the courses by the curriculum.

For research a high power computational facility is required. The institution must acquire high capacity servers (1 terra bite RAM). These servers will be supporting the computation work and internet facility.

VI CONCLUSION

In this study an attempt has been made to eliminate the superfluous curriculum burdens on the mechanical engineering students by reducing the superfluous credits. **Twenty core** and **four elective** courses have been proposed with a total of **ninety six** credit hours. Core courses have been designed to make the solid foundations in the areas of mechanics of materials,

mmeybodi@aut.ac.ir

thermodynamics, heat transfer, fluid mechanics and machinery, engineering economics and management, mechanical vibration and control, manufacturing and engineering graphics, instrumentation and power plant engineering, and mechanical design. Besides this, four electives have been proposed to attain mastery in one of the fields like, control engineering, thermal engineering, aerospace engineering or production engineering. Few courses have been proposed with laboratories wherever necessary. Courses can easily be offered, three per semester in eight semesters. Besides this, the faculty quality, evaluation of students, faculty student ratio and, student counseling and advising have been discussed. Moreover infrastructural facilities like, computational/internet facility, library facility and laboratory facilities have been analysed. These all propositions are expected to reduce superfluous curriculum burdens on the students.

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TABLE VI
DEGREE CURRICULUM FOR BS MECHANICAL ENGINEERING

First Year (Freshman)

First Term

Code	No.	Course Title	U
GE	101	Computer Appl. in Eng.	4
PHYS	101	Vect. Tensors & Solid Geometry	4
MATH	101	Ordinary & Partial Dif. Eqs.	4
		Total	**12**

Second Term

Code	No.	Course Title	U
MATH	102	Complex Var., Prob. & statistics	4
PHYS	102	Classical Mech. and Thermodyn.	4
GE	102	Engineering Design	4
		Total	**12**

Second Year (Sophomore)

First Term

Code	No.	Course Title	U
PHYS	211	Electrodyn. & Circuit theory	4
ME	271	Thermodynamics & Machines	4
ME	231	Materials Science	4
		Total	**12**

Second Term

Code	No.	Course Title	U
GE	202	Engineering Mechanics	4
GE	212	Continuum Mechanics	4
ME	222	Manufacturing & Eng. Graphics	4
		Total	**12**

Third Year (Junior)

First Term

Code	No.	Course Title	U
ME	371	Fluid Mechanics	4
ME	341	Mechanics of Machinery	4
ME	351	Mechanics of Materials	4
		Total	**12**

Second Term

Code	No.	Course Title	U
ME	342	Control and Vibrations	4
ME	352	Mechanical Design	4
ME	372	Heat Transfer	4
		Total	**12**

Summer Training Term

Code	No.	Course Title	U
ME	390	Professional Training in Mech. Eng.*	0
		Total	**0**

* Upon completion of 72 Credits or Junior Standing.

mmeybodi@aut.ac.ir

Fourth Year (Senior)

First Term

Code	No.	Course Title	U
XE	xxx	Adv Engineering Electives	4
XE	xxx	Adv Engineering Electives	4
ME	421	Instr. & Power Plant Eng.	4
		Total	**12**

Second Term

Code	No.	Course Title	U
XE	xxx	Adv Engineering Electives	4
XE	xxx	Adv Engineering Electives	4
GE	402	Eng. Econ. & Management	4
		Total	**12**

Total credits required in the Degree Program: 96

TABLE VII
FOURTH YEAR ELECTIVES

1. Control Systems

Code	No.	Course Title	U
EE	411	Intro. to Microprocessors with lab.	4
EE	412	State Variable Control Sys. With lab.	4
ME	401	System Dynamics & Control with lab	4
ME	422	Robotics with lab	4

2. Thermal Engineering

Code	No.	Course Title	U
ME	431	Air conditioning with lab.	4
ME	432	Refrigeration with lab.	4
ME	441	Convective Heat Transfer with lab.	4
ME	442	Heat Exchanger Design with lab.	4

3. Aerospace Engineering

Code	No.	Course Title	U
ME	451	Aircraft Struct. and Design with lab.	4
ME	452	Flight Mech. & propulsion with lab.	4
ME	461	Finite Element Analysis with project	4
ME	462	Aerodyn. & Gas Dynamics with lab.	4

4. Production Engineering

Code	No.	Course Title	U
ME	471	Manufacturing Processes with lab.	4
ME	472	Materials Mech. Behavior with lab.	4
ME	481	Solid Mechanics with lab.	4
ME	482	Modern Materials with lab.	4

mmeybodi@aut.ac.ir

Distance Learning in Architectural Design Studio: Two Comparative Studies with One Onsite Teaching

Neander F. Silva
&
Ecilamar M. Lima
Universidade de Brasilia
Faculdade de Arquitetura e Urbanismo
neander@unb.br, ecilamar@unb.br

Abstract – **In this paper three teaching experiences of supervising and discussing architectural design projects are compared. They were developed to extend access to students living in different states of Brazil. It also provided an opportunity for testing whether the quality of teaching architecture at distance was at least the same as on site. The first teaching experience was carried out through on site teaching. The second was developed through a low cost real time collaboration system, RTCS, based on a hosted service. The third involved developing the same activities through a low cost RTCS based on dedicated server. The results show, particularly in the third experience, that the distant education in architecture is viable and effective.**

I. INTRODUCTION

Distance learning in Architecture is incipient. The main difficulty is due to the need for teachers and learners to simultaneously see, manipulate, and discuss the artifacts being designed in the same environment.

The high cost in the communication systems for discussing design in real time at a distance is a major issue. Most research has focused on expensive setups [1]. We call expensive those setups budgeted above US$8,000.00. This limit was defined in accordance to how much we could afford in setting up the server side in our particular institution, University of Brasilia, Brazil. We also set as a low cost parameter the limit of US$1,500.00 in software and hardware plus no more than a US$50.00 monthly DSL connection fee for each client's side of the system. Besides the cost, another important criterion in defining the meaning of 'affordable' was the degree of availability of the technology involved in the implementation of the communication system: all parts should be made of 'commodity' components, widely available technologies, including hardware (Intel or AMD PC's) and operating system (Windows).

We believe that real time collaboration systems, RTCS's, particularly desktop sharing, application sharing and voice chatting, connecting the server via a standard high speed network and the clients via DSL, have the potential to provide above mentioned low cost environment for architectural distant learning.

Most publications in RTCS's involve system specification and evaluation [2]. Few authors focus on how much RTCS's environments are equivalent with onsite teaching or how these technologies affect learning in the design studio.

Keegan [3] and Simonson et al [4] regarded equivalence to on site education as the key criteria to assess the success of distance learning. Ko and Rossen [5] consider that online synchronous courses can even compete favorably with traditional ones.

We describe in this paper an experiment comparing teaching, supervising and discussing architectural design projects through two different RTCS's setups with developing the same activities on site. A group of students taught on site was compared with two others taught through RTCS's. In all these three situations the same contents were delivered and a variety of open source and commercial software were used for architectural education. Among them the principal tools were the image editor GIMP (http://www.gimp.org), the solid modeling, rendering and animating software FormZ (http://www.formz.com) and the environmental simulation tool Ecotect (http://www.squ1.com).

II. A LOW COST RTCS SETUP

Our project of setting up a low cost RTCS has been developed so far in two phases as described in the sessions bellow.

A. A hosted solution

In the initial phase we tested an alternative setup with the lowest cost in the market. This resulted in using a RTCS hosted by the web server of another organization (http://www.gotomeeting.com). One of the problems with this setup was that this particular system did not provide a voice chat over IP, but over the telephone system. Since the provider was in a different country this option was not viable for us because all participants would have their telephone lines billed at international call rates.

Therefore, we decided to use just the graphical interface resources of this particular system, that is, the desktop sharing, application sharing and session recording. However, voice chatting was essential for us in order to free the hands of the participants from having to type at text chatting boxes while at the same time to perform graphical actions in desktop and application sharing. For this reason we decided to use an additional hosted system which did not support desktop and application sharing but offered free voice chatting (http://messenger.yahoo.com/ and http://voice.yahoo.com).

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The overall cost of this solution for our school was very low: US$49.00 per month paid only by the organizer of the meetings.

The main problem with this solution was the reliance on three different servers, among which we had limited control upon only one of them. This resulted in considerable instability and poor performance due to the distance between our country and the country where the hosted systems were based (GotoMeeting and Yahoo). The system component that most suffered with this limitation was voice chatting where the delays frequently went beyond five seconds. This was probably due to the fact that the signal had to 'travel' from the host's computer to the server abroad and only then back into our country to the other participants computers.

B. A solution with our own dedicated server

In the second phase of our project we sought to set up a system on our own dedicated server so that we could have full control of RTCS's performance, while still using only 'commodity' components.

We managed to setup the server side of our RTCS, within the budget limit specified above, using an AMD based machine (Sempron 3000 Processor, with 3GB RAM and a 40 GB HD), running Windows Server 2003 and the RTCS application Linktivity (http://www.linktivity.com). The server hardware and operating system cost all together about US$3,000.00 and the RTCS application cost about US$5,000.00. Our server was connected directly to the University of Brasília high speed network without extra costs for our Faculty.

The clients accessed the RTCS over standard DSL connection, if they were outside de University campus, using several different Internet service providers. Teachers and tutors usually accessed the system from within the University's network.

The meetings were held in the evenings, between 7 pm and 10 pm, because the experiment was part of a Computer-aided Architectural Design Post-Grad Program that was run at night for part-time students [6 - 8]. This brings the advantage of using the University's network and the Internet in a time when the overall demand is significantly lower than pick times (9 am to 5 pm).

The RTCS which we have setup allows a meeting of 10 persons, involving students and two teachers. We have worked with two successive meetings lasting about one hour and a half each one. In these meetings the teachers deliver tutorials, discuss design projects and clarify doubts of previous classes in real time. The system provides several resources, but we have mostly used desktop sharing, application sharing and voice chat simultaneously.

We have had participants from several different locations in our country, some of them connecting from distances as far as 2,000 km.

Figure 1 below shows a view of the desktop of a meeting host.

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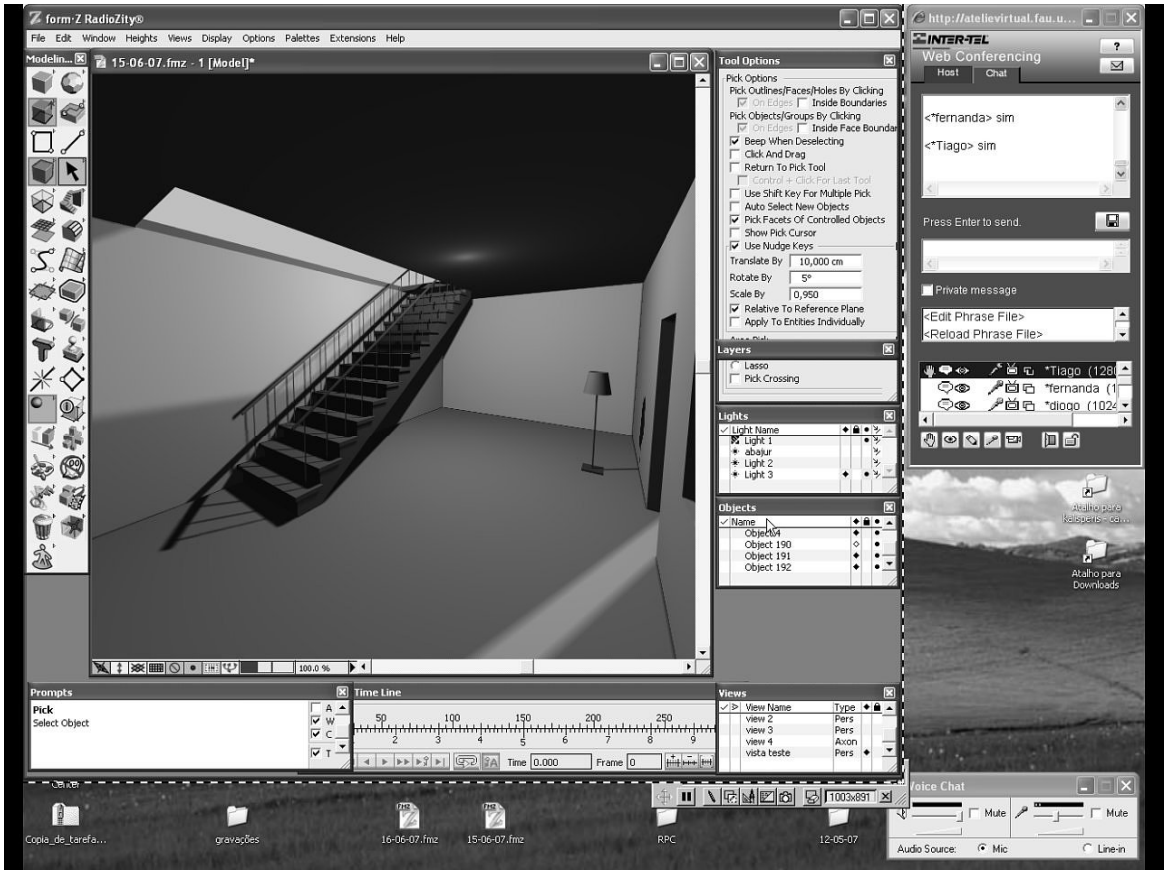


Figure 1 – A view from a host desktop.

The area within the dotted line square is visible to all the other participants. The window on the right upper corner is the host control panel containing also a text chat window.

The viability of simultaneously seeing, commenting (through voice and sketching) and manipulating three-dimensional computer representations of architectural artifacts was vital for our project. Therefore, the amount of delay was a key criterion in assessing our experiment. We found out that the second phase solution, that is, the dedicated server one reduced substantially the delay in relation to the previous phase.

Figure 2 below shows the desktop of a host seeing a 'viewer' window containing the presentation of another participant in his/her own computer.

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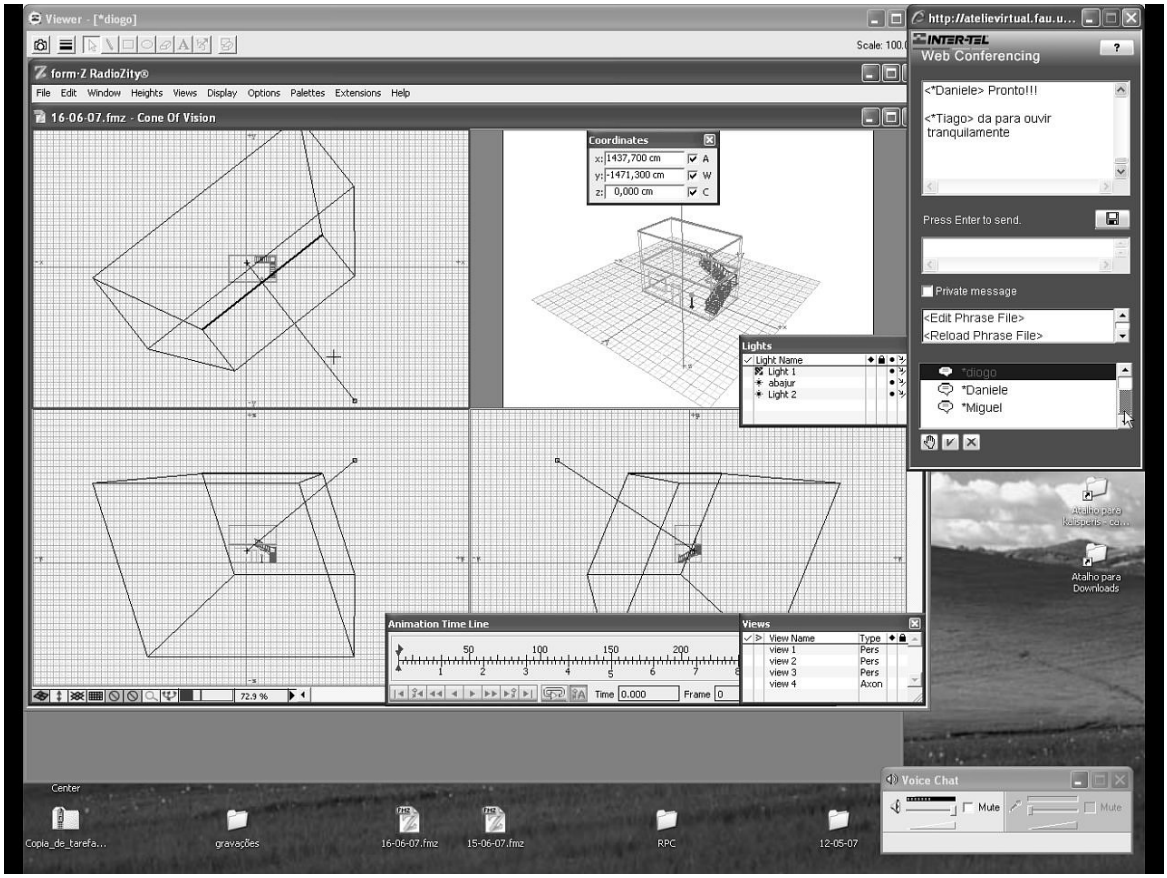


Figure 2 – A host desktop is showing a presentation of a long distance class where students were being taught how to define an internal view of a room.

III. ASSESSMENT

In this section we compare the setups organized in three groups according to the resources available in each situation: on site; at a distance – hosted by third party web server; and at a distance – in our own dedicated server, through the same set of questions.

The questions presented below were thought, as much as possible, to constraint the universe of possible answers into a yes or a no. Several pairs of questions are mutually excluding, such as questions 3 and 5, 4 and 6, 9 and 10, etc. Other questions are independent, such as questions 8, 18 and 19.

The Table 1 below shows the results of the comparative study of the three mentioned experiences:

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TABLE I
COMPARATIVE STUDY

Question	On site	At a distance (hosted)	At a distance (dedicated server)
1. Did the communication system affect the learning experience?	yes	yes	yes
2. Was the learning pace different from the others?	yes	no	no
3. Was the voice communication speed slower in any way?	no	yes	yes
4. Was the voice communication speed significantly slower (more than 5 seconds)?	no	yes	no
5. Was the voice communication speed faster in any way?	yes	no	no
6. Was the voice communication speed significantly faster (more than 5 seconds)?	no	no	no
7. Were the variations in communication speed frequent?	no	yes	no
8. Did the learning experiment require changes in different teaching methods?	yes	yes	yes
9. Did the learning environment impose particular constraints on the lectures?	no	yes	yes
10. Did the learning environment offer advantages for the lectures?	yes	no	yes
11. Did the learning environment impose constraints on tutorials?	no	yes	no
12. Did the learning environment offered advantages for tutorials?	no	no	yes
13. Did the learning environment impose constraints on group discussion?	no	yes	no
14. Did the learning environment offered advantages for group discussion?	no	no	yes
15. Did the learning environment imposed constraints on individual participation?	yes	no	no
16. Did the learning environment offered advantages for individual participation?	no	yes	yes
17. Did the learning environment induce any loss of attention in relation to the other group?	no	no	no
18. Did the learning environment imposed constraints on architectural design supervision?	no	no	no
19. Did the learning environment offered advantages on architectural design supervision?	no	yes	yes
20. Was the level of student absences visibly higher than the other group?	no	yes	no
21. Was the level of drop out visibly higher than the other group?	yes	no	no
22. Did the learning experience encourage a higher rate of students per teacher?	yes	no	no
23. Did the students learned more in this set up?	no	yes	yes

Generally speaking the learning experience at a distance using a dedicated server was better than the one using a hosted system by a third part web server. The speed of voice communication of the dedicated server was yet slightly slower than on site experience, though not as much as in the case of the hosted system. There was no delay in the graphic and text transmission and the images were of high quality.

It is important to stress that the learning process was successful in the third learning environment and permitted students from different states to access the classes that otherwise they would not be able. The RTCS allowed also each student to present his or her design, receive the comments and colorful annotations made by the teachers, besides clarify their doubts under the observation of all the other participants in real time.

One of the surprising results was an improvement in the participation of the students. Some of them who in an on site environment would remain silent had a higher rate of participation, making questions, presenting their works, etc. Differently of what happens in the on site class, in the RTCS a student would make a question, reply to the teacher again and again until his or her doubt was completely clarified pointing to obvious gain to the learning process. Considering that the students learn more in an environment set up where they are able to make more questions our third learning experience was the most successful one.

Above these advantages there is another one equally important. Owning to the fact that the tutorials were recorded, the students could watch them again as much as they needed and all the class could benefit from the questions made and explanations given.

IV. CONCLUSION

The overall results show clear advantages in the third teaching environment, although there were yet some technical problems to overcome regarding system configuration, connection speed and reliability. They required development of different meeting techniques. No evidence was found for increasing the rate of students per teacher. However, the overall results were promising and there were important gains to the learning process. The RTCS we used were of a low cost and a viable alternative to expensive setups. Above all, our third experience with long distance teaching of design studio was of higher quality, perhaps better than onsite because allowed more questions from the students to be made and gathered all the information in the same place. Also it facilitated the learning of a new subject, was helpful to clarify doubts and reinforced a taught subject.

The reasons for the greater participation of shy students in the discussions held under the RTCS are still to be objectively determined by future research. However, we believe that this may be somehow related to the greater sense of security and less physical exposure provided by a virtual meeting in which contact was made without video showing people's faces.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Design Computing Education: A Comparative Study Among Learning Environments

Neander F. Silva
&
Ecilamar M. Lima
Universidade de Brasilia
Faculdade de Arquitetura e Urbanismo
neander@unb.br, ecilamar@unb.br

Abstract - Four learning experiments aiming to verify how much different design computing education methods produce different results are described in this paper: an undergrad software-oriented course, an undergrad project-based course, a post grad course with a hybrid teaching approach and a project-based Computer-Aided Architectural Design, CAAD, post grad diploma program.

II. INTRODUCTION: THE PROBLEM AND HYPOTHESIS

Many have argued that new technologies imply in new ways of working [1]. It involves a controversial issue between method and media. A new technology means new resources but not necessarily a new way of working. The availability of a new technology does not mean that it has been used in its full capacity. An analogy was told about a war between Anglo-Saxons and Franks, in which the first had the technology of the stirrup but did not understand fully the potential of this device. Then appeared a Frank warrior that understood the capabilities of the stirrup lead its country to win the war. He perceived that the stirrup permitted the rider to keep his seat and to deliver a blow with a lance combining his weight and speed of his horse [2][1]. A more recent analogy is the way a car was used when it was first invented. It was named as horseless carriage and could run at 20 km per hour. When the car was invented it looked like a carriage. It was only when its own potentials were understood that it started being designed with new features and used in different ways from the carriage.

In architecture these analogies apply to the computer-aided design process, particularly to its teaching approach and methods. Many architects still use computers in the design process as they used earlier technologies. Most of architects use computers to represent what they have already decided rather than to conceive their own design ideas. Although this may not happen everywhere, it is yet the case in many architectural offices.

The following practices exemplify this trend: firstly, the emphasis is still on increasing productivity, particularly in drafting, rather than on producing better designs. This is due to the fact that computers allow the reuse of previous solutions, through copying and pasting and increases enormously the speed of drafting and printing. For this reason many believe that the objective of the use of computers is just greater productivity. Secondly, computers offer major advantages over traditional tools, such as 3D modeling, abstract and realistic rendering, natural and artificial lighting calculations, virtual environments, etc. However, those resources are mostly used only for presentation rather than design decision making. Thirdly, many architects still design by documenting the final product rather than by modeling objects and exploring different alternatives.

Why so many architects yet use computers mimicking earlier technologies? We believe that one of the major reasons for that resides on the learning method by which most architects were introduced to computer technology. A recent survey [3] shows that most architects are taught computers through the production of several independent orthographic representations, such as floor plans, sections and facades. The computer's potential to represent the artifacts in a fully integrated 3D object-oriented environment is rarely taught. That survey also shows that most architects learn to use computers by representing existing buildings. The results are courses predominantly command-based or software-oriented rather than application-oriented. The possibility of integrating computers into the decision making process characteristic of designing new buildings is also not taught. Most architects are taught with the basic presupposition that the computer's constraints are the same of the earlier technologies. Not surprising, the same survey shows that most architects tend to continue using computers in the same way they were first taught.

Therefore, we believe that the solution is of educational nature and has to be based fundamentally on three points: firstly, teaching must start from 3D instead of 2D. We must take advantage of the computer's capability of representing

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objects in integrated environments from which all drafting information can be later extract.

Secondly, teaching must be based on architectural issues rather than software commands or structure. The major issue should be the teaching focusing on the process of architectural designing allowing testing of different solutions, visualization and integration among its various parts, feedback and changes as much as necessary.

A Project-based Learning - PBL is a teaching method [4][5][6][7] that can be used in CAAD education allowing students into a new understanding of the potential of computing in the design process. One of the basic assumptions of PBL is that students learn better when teaching takes place in true-to-life activities. There is no separation between learning the concepts and only after that applying the acquired knowledge. In a PBL CAAD environment students are necessarily pushed beyond merely using the computers to represent what has already been decided into exploring the new possibilities that computers offer in the design decision making process. In this type of learning environment students are also encouraged to find new solutions rather than simply to describe or reproduce previous ones.

Thirdly, teaching must take place by using innovation-based computer systems rather than automation-oriented ones. Several CAAD programs today emphasize the reuse of previous solutions in the form of pre-defined components in order to increase productivity. For instance, the user is required to choose at the beginning of the design process what type of wall will be used in the project including the specification of construction materials and their properties. If this is mandatory in particular system then it becomes inflexible not allowing the designer to use abstractions at the beginning of the design process neither to develop new components. An innovation-based computer system may include pre-defined components, but it must be flexible enough to allow for abstractions particularly at earlier design stages and also allow the development of new solutions anytime in the process.

In the following sections we compare four teaching experiences verifying the students' predominant understanding and practice computer-aided design at the end of each of them. For this purpose we used the following blocks of questions:

Block I:

1. Was there an indication that the students understood the computer as only a replacement of traditional design tools?
2. Was there an indication that the students sometimes understood the computer as a tool offering new possibilities?
3. Was there an indication that the students predominantly understood the computer as a tool offering new possibilities?

Block II:

4. Did the students only design or draw by documenting in 2D?
5. Did the students design or draw by documenting in 2D but also by modeling artifacts?
6. Did the students predominantly design or draw by modeling artifacts in 3D?

Block III:

7. Did the students explore design alternatives?
8. Did the students mostly tend to stick to the first solution?
9. Did the students explore several different design alternatives in design process?

Block IV:

10. Were computers used just for representing what had been already decided?
11. Were computers sometimes used in decision making process of design?
12. Were computers mostly used in the decision making process of design?

II. A SOFTWARE-BASED UNDERGRAD COURSE:

"Computer Graphics", CG, is a mandatory course in our undergraduate program. This course is delivered in the first year of the undergraduate program and it is fairly traditional, with emphases on 2D drafting and on representing existing buildings. Students are taught to work with 2D environments and to represent documents rather than artifacts.

We analyzed its results in terms of the twelve questions stated in the previous section. We assessed the results in terms of how much the students used the computers in the design process rather than to represent the final product. The results are very predictable as seen in the section 6 (A comparative study).

III. A PROJECT-BASED UNDERGRAD COURSE:

"Computer-Aided Architectural Design", CAAD, is an elective course taught to the fourth year students of our undergraduate program. It is worth of note that "Computer Graphics", CG, is a pre-requisite for CAAD therefore with implications in the learning process. This course is design-

mmeybodi@aut.ac.ir

oriented, but it deals with students that learned, in CG course to use computers mimicking the previous technologies. Although the teaching method used in CAAD is very different from the course previously mentioned, the students practice is greatly influenced by the way they initially learned how to use computers in CG. The results are not as good as the next two courses whose students did not learn computers as in CG that emphasizes 2D drafting and representing existing buildings. We analyzed this course results with the same criteria used for the previous one above. Please refer to section 6 (A comparative study).

IV. A POST GRAD COURSE WITH A HYBRID TEACHING APPROACH:

"Theory and Practice of Design Computing", TPDC, is a course of our master's program. The audience of this course is composed mostly of professionals in the range of 25 to 40 years old including some few mature architects. This course started with traditional lectures to deliver the contents of introduction to computing and computer graphics, and progressed towards a design based approach of teaching in which students were lead to find and test solutions for their projects. We analyzed its results with the same criteria used in the ones above. Please refer to section 6 (A comparative study).

V. A PROJECT-BASED COMPUTER-AIDED ARCHITECTURAL DESIGN POST GRAD DIPLOMA COURSE:

Computer-aided Architectural Design Post Grad Diploma, CAAD PG Dp, is a program in our school that lasts 18 months. A design based approach is adopted since the conception until the communication to the construction site. Its audience is fairly similar to the master's course TPDC. The detailed presentation of this Program has been subject of some of our previous publications [8][9][10]. The results show several advantages in the design process of these students. They fully understood and took advantage of the computer to explore ideas throughout the design process since the conception. They explored different design alternatives. They designed by modeling objects of the real world rather than simply representing documents. Please refer to section 6 (A comparative study).

VI. A COMPARATIVE STUDY:

The Table 1 next page shows the results of the comparative study using the blocks of questions described earlier in this paper:

TABLE 1. COMPARISON AMONG DIFFERENT LEARNING CAAD EXPERIENCES.

Course	CG	CAAD	TPDC	CAAD PG Dp
Block I				
1. Was there an indication that the students understood the computer as only a replacement of traditional design tools?	Yes	No	No	No
2. Was there an indication that the students sometimes understood the computer as a tool offering new possibilities?	No	Yes	No	No
3. Was there an indication that the students predominantly understood the computer as a tool offering new possibilities?	No	No	Yes	Yes
Block II				
4. Did the students only design or draw by documenting in 2D?	Yes	No	No	No
5. Did the students design or draw by documenting in 2D but also by modeling artifacts?	No	Yes	Yes	No
6. Did the students predominantly design or draw by modeling artifacts in 3D?	No	No	No	Yes
Block III				
7. Did the students explore design alternatives?	No	Yes	Yes	Yes
8. Did the students mostly tend to stick to the first solution?	n/a	Yes	Yes	No
9. Did the students explore several different design alternatives in design process?	n/a	No	No	Yes
Block IV				
10. Were computers used just for representing what had been already decided?	Yes	No	No	No
11. Were computers sometimes used in decision making process of design?	No	Yes	Yes	No
12. Were computers mostly used in the decision making process of design?	No	No	No	Yes

The questions above were thought, as much as possible, to constraint the universe of possible answers into a yes or a no. Blocks I, II and IV contain questions that are all mutually excluding. In Block III only questions 8 and 9 are mutually excluding.

Each of these blocks contains questions that also aim to verify how closely the following objectives were achieved: 1. to teach the students to perceive the computer as a tool providing new possibilities for designing; 2. to have the students designing from modeling artifacts; 3. to have the students exploring several different alternatives in the design process; 4. to have the students using computers in the design decision making process. For instance, an answer yes to the third question of each block would indicate that our objective was achieved; an answer yes to the second question of each block would indicate that our objective was

mmeybodi@aut.ac.ir

partially achieved; an answer yes to the first question of each block would indicate that our objective was not achieved.

Although we delivered the teaching in all four courses described earlier, we had a variable degree of freedom in defining the recruitment criteria, the contents and the methods in each one of those experiences. In the course CG we had to work under great constraints for we did not have the power to define neither the recruitment criteria nor the contents. We had a very limited power to define even the methods. In the course CAAD we also did not have the power to define the recruitment criteria, because the students enrolled in it had to take CG as mandatory course. However we did have the opportunity to define contents and methods of CAAD. In the course TPDC we could partially define the recruitment criteria and fully define its contents and methods. In the CAAD Post-Grad Diploma we had the freedom to fully define all these variables: contents, method and recruitment criteria. This variety of constraints resulted in different teaching experiences and provided an opportunity for the comparison at hand.

The results achieved in CG were, as predicted, very disappointing with none of the objectives achieved. The results of CAAD were better with all the 4 objectives partially achieved. The results of TPDC were even better with one objective fully achieved (1. to have the students to see the computer as a tool providing new possibilities for designing) and the three others partially achieved. The results of the CAAD Post-Grad Diploma were very promising with the all the 4 objectives fully achieved.

Figures 1 and 2 illustrate the use of computers for decision making. Figure 1 shows a radiosity based rendering of an auditorium. Having realized the inadequacy of the initial lighting design the student proceeded to modify it until achieve a better result such as in Figure 2.

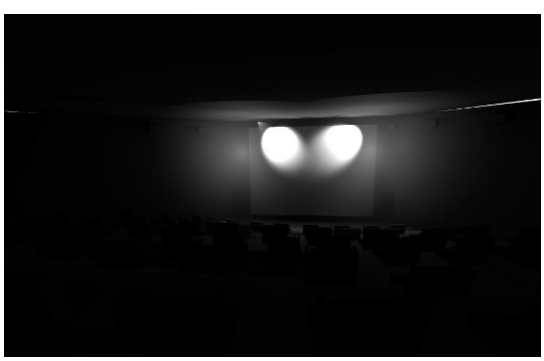


Figure 1. First radiosity study.



Figure 2. Second radiosity study.

These figures above are examples of using computers for decision making in the design process in the CAAD Post-Grad Diploma. They show the importance of testing different alternatives to improve solution instead of sticking to the first one as it happens when computer is used mimicking traditional technology.

7. CONCLUSIONS:

It was our primary concern in this paper to compare the results of different teaching methods that encourage exploring different alternatives in the conceptual design phase of design with those that use computers for 2D drafting or representing existing buildings. We believe we have demonstrated that the learning approach set up at the CAAD Post Grad Program produced promising results in terms of encouraging professionals to effectively use computers in architectural design in new ways rather than mimicking earlier technologies. Students have demonstrated in CAAD Post Grad Program the capability of using computers to represent artifacts rather than documents, to explore design alternatives and to incorporate new possibilities in the design thinking process which are not available in previous technologies (such as time, motion and immersion). The comparative results (Table 1) show that only the students of this post grad course fully understood how to use the computer to benefit the design process.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Software Technique for Performance Evaluation of a Volumetric Screw Dosing System for Agro-Foods Bulk Solids

D. Ola, M. Manescu, L. Gaceu

Transilvania University of Brasov, Romania
danielola@yahoo.com; memanescu@yahoo.com; gaceul@unitbv.ro

Abstract: **The paper presents a software application that monitors an experimental dosing stand presenting the influences of the working parameters upon the dosed debit flow of the bulk material. The automatic software allows the dosing system to work as a "learning" device, and to act according with the flow behavior of different bulk solids or with the situations encountered during the dosing operation.**

I. INTRODUCTION

Batching of ingredients is one of the main applications of the dosing operation in food industry. Small variations in the doses of the product ingredients are generally not detectable in the final product quality, but to make the production more efficient, especially when the final product consists of expensive materials, it is crucial to ensure a precise and rapid dosing of these ingredients in a time interval as small as possible. Even more, in the case of packaging technique, the profitability of the final product and of the packaging operation is directly dependent on the time taken for the batching of the desired portion.

Horizontal screw feeder dosing systems (fig.1) batch the material *5* by displacing an amount of material that is hold between two screw flights *6* and transport it on a linear displacement. The screw feeder *6* is horizontally positioned to assure in this way a better control of the material flow, avoiding the flushing flow of materials that have free flowing characteristics [1].

The feeding of the dosing system's hopper *1*, is made periodically at the moment when it is reached the established minimum level of material in the hopper. The screw feeder is driven by a belt transmission *4* powered from an electric motor. The electric motor is controlled by a microcontroller automation unit *2* that is linked to a computer *3*.

The final adjustments for the fine dosing are made by adjusting the rotational speed of the screw feeder to a lower value and by gradually closing up the sliding gate *7* to minimize the flow outlet section for the material and to allow that only small amounts of material to be fed on the weight scale *8*.

In order to monitor the volumetric debit flow of the dosing stand, a rotational incremental optic sensor was mounted on the driving shaft of the feeding screw so that by counting the number of rotations performed by the dosing screw feeder. The theoretical volumetric flow is calculated by taking in account the chamber filling coefficient that is dependent on the flow characteristics of the material. The volumetric precision of this dosing system is relatively good if a proper material flow can be assured in such way that mechanical bridging above the feeding screw or flushing of material will be avoided [1].

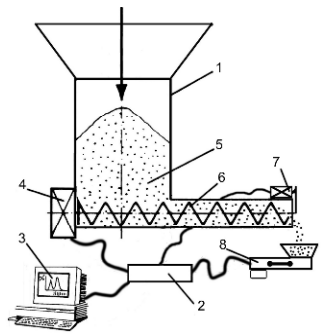


Fig.1. Schematic sketch of the dosing stand system with horizontal full flight screw feeder.
1 – feeding bin; 2 – microcontroller automation unit; 3 – computer; 4 – drive group for the dosing screw feeder; 5 – bulk solid material; 6 – dosing screw; 7 – section flow adjuster and closing up sliding gate; 8 – weight scale.

II. AUTOMATIC CONTROL OF THE DOSING STAND

For the monitoring in real time of the dosing process parameters an automation unit was designed and built for the volumetric screw dosing system. The automation control unit will command the two active components, respectively the dosing screw feeder and the sliding gate, as it is represented schematically in figure 2.

For the processing of the input data obtained from the sensors that monitor the dosing process, the automation control unit uses a microcontroller produced by Atmel, type Atmega 8535. This microcontroller was chosen because it's architecture and features presented many advantages, as a very good execution speed of the instructions for the applications used in controlling of the dosing system (16 Million Instruction Per Second); the existence of a SPI port to communicate with the signal analog-digital convertor AD7730 used for the tensometric weight cell; PWM capabilities to control the angular velocity of the electric motor; poses 4 parallel ports to command of outputs like: indicator led, LCD monitor or for to

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 392–395.
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be used for the receiving of data from operator keyboard; simple communication connection with the computer by using the RS232 interface.

The basic concept for the microcontroller automatic function is that the controlling of the dosed flow is made by reading the tensometric weight cell value converted by the integrate AD7730 and compares this value to a set point value that represents the targeted dose value. By performing a subtraction operation between the two values it is obtained a result that will represent the proportional error of the dosing operation that needs to be corrected. When the subtraction value reaches the interval for the fine dosing stage the system output signal will change according to the error value and will adjust the rotational speed of the motor to a lower value in assuring this way that only small amounts of material will be fed in the weighing vat. At the same time the microcontroller will command the ULN2803 power integrate circuit that can command the rotational movement of the stepper motor which drives the closing gate of the screw feeder chamber. This sliding gate will shut down gradually, based on the instructions given from the microcontroller, to decrease the evacuation section of the bulk material, ensuring this way a better flow control so that only small portions will be fed in order to reach the final weight value of the batch and to prevent uncontrolled flows in the weighing vat.

The analog-digital conversion of the signals from the weight sensor is performed by an integrate made by Analog Devices type AD7730. This integrate AD7730, realizes the analog – digital conversion of the signals from the resistive transducer weight cell and communicates these digital signals to the microcontroller on the Serial Peripheral Interface (SPI) port [2].

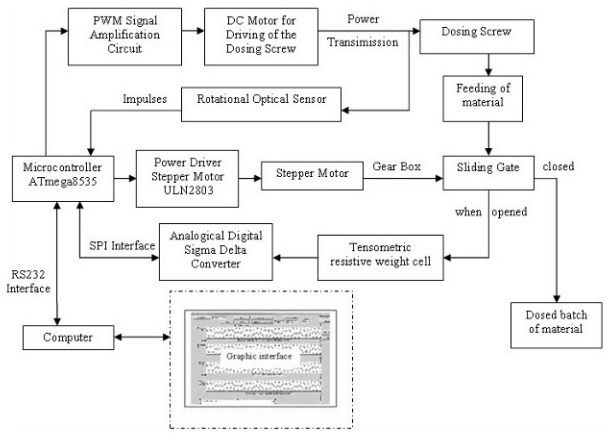


Fig. 2. Schematic representation of the automatic control of the volumetric dosing system with full flight dosing screw.

The command operations for the control of the actuators of the dosing system.

The *control of the rotational movement of the dosing screw feeder* is realized by the microcontroller that sends Pulse Width Modulation (PWM) signals to the power integrate L6203. This integrate is capable to command an electrical DC motor with maximum voltage of 42V and current up to 4A. By controlling the electric motor tension, the rotations and the speed of the dosing screw can be adjusted in real time.

The *control of the rotational sliding gate* for the gradual decreasing of the flow section for the dosed material has the purpose to obtain greater precision on the fine dosing phase. The rotational sliding gate is positioned at the outlet of the screw chamber and is driven and controlled with a stepper motor. The stepper motor is powered through amplified signals by the ULN2803 power integrate circuit that receives Transitor-Transitor Logic signal (TTL) from the microcontroller. The ULN2803 is foreseen with 8 levels of Darlington amplification that can command the stepper motor with a tension equal with 50V and an intensity of 500 mA.

Monitoring of the material dosed flow.

The monitoring of the *volumetric debit flow* is achieved by monitoring of the screw rotations and by multiplying this value to the constant value of the subtraction geometrical volume of the screw feeder. The rotations of the dosing screw are monitored using an incremental optical sensor that creates digital signals from the aperture disc mounted on the driving shaft of the screw feeder. This optical sensor is directly linked with the microcontroller, that will count the number of impulses generated by the optical sensor and for each impulse counted will allocate 10° of angular displacement.

Mass flow monitoring of the bulk solid material is performed by converting the analog signal from the resistive tensometric weight cell which is connected to a weighing vat for the collecting of the dosed material. The weight cell is working on the tensometric principle that modifies the value of the resistance of the tensometric bridge with the variation of the weight of the material fed in the weighing vat.

mmeybodi@aut.ac.ir

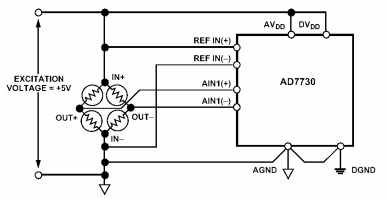


Fig.3. Sketch representing the connections of the weight cell with the weight monitoring integrate AD7730 [2].

The weighing cell is connected directly to AD7730 integrate (s. fig. 3) without any prior amplification because the conversion of the analogical signal is completely processed by the AD7730 integrate through the specialized components which are built in his architecture. The result of one conversion represents a numerical value of 24 bits and has a resolution of the conversion of 230.000 units for the receiving tensions on the interval -40mV to +40mV [2].

The microcontroller communicates with the AD7730BN integrate through a Serial Peripheral Interface (SPI) that uses the following three connections from the microcontroller: data receiving connection (MISO - Master Input, Slave Output), data transmission connection (MOSI - Master Output, Slave Output) and one connection for the synchronization of the data (SCK – Serial Clock). Connections between the AD7730 and the tensometric bridge are direct and simple for this type of application. The bridge configuration shown in figure 3 is a six-lead configuration with separate return leads for the reference lines. This set up allows a force/sense effect on the load cell excitation voltage, eliminating voltage drops caused by the excitation current flowing through the lead resistances [1].

The *user interface software* can activate the following commands for the dosing stand: launching of the calibration procedure, establishing of the dosing parameters, start of the dosing process, finalizing of the dosing process, saving of the monitored data. The microcontroller communicates through the communication RS232 port with the PC and this data port is used by the software to receive and to send data for the full control of the dosing parameters.

The software application developed for the automation device, offers for monitoring purpose real time graphs of the measured weight, the theoretical debit flow, the angular displacement and the angular speed of the dosing screw. At the end of one dosing batch the user interface program will provide the possibility to save all the data gathered from the sensors, in a database worksheet.

III. USER INTERFACE SOFTWARE FOR THE MICROCONTROLLER COMMAND

The dosing stand control software has a friendly graphical user interface with features that can activate the commands of the dosing stand, such as: launching of the calibration and tare procedure, establishing of the dosing parameters, start of the dosing process, ending of the dosing process, saving of the monitored data. The microcontroller communicates through the communication RS232 port with the PC and this data port is used by the software to receive and to send data for the full control of the dosing parameters.

Launching of the Calibration and Tare Procedure

The calibration procedure is a very important step in the adjusting of the signal received from the weight cell of the dosing system. Therefore the dosing stand has included the procedure of realizing of the calibration by using standard etalon masses. The etalon mass is placed on the weight cell of the dosing stand and the weight response is compared to the known etalon mass. The difference is then shown in the text box and the program will decide if the value is found in the limits of the tolerance interval and if not the program will change an internal calibration constant.

The tare procedure is launched at the beginning of the dosing procedure by zeroing down the reading value of the empty weighing vat at the beginning of the dosing operation. This procedure is important in order to ensure that the packaging material is not included in the value of the dosing batch.

Establishing of the Dosing Parameters

The dosing operation begins with the establishing of the dosing working parameters that will be introduced by the user in the fields for the setting up of the dosing procedure. For the dosing procedure the student has to introduce the interval value for the raw dosing stage during which the material will be fed at the maximum speed. This interval has to be coordinated with the flow characteristics of the dosed material in such way that when the dosing speed is switched from the raw dosing phase to the fine dosing phase the material flow will still be under control. Students can learn by trial and error and observe the response of the system for these parameters.

Start of the Dosing Process

The graphic user interface will launch the dosing operation by activating the *START* launch switch. The beginning of the dosing operation will open the real time monitoring graphs that will show the instant mass debit flow, the instant theoretical volumetric flow, the number of rotations and angular speed of the screw feeder. At the beginning of the dosing operation the user can also choose to save the data of the dosing operation by checking one confirmation box and specifying the location of the data files.

Ending of the Dosing Process

The user can abort the dosing operation at anytime during the dosing operation by activating the *STOP* switch found on the graphical user interface.

The software developed was used for determinations to analyse the dosing of different agro-food materials and the results of these experiments resulted in plots with the weight variation of the doses that could be compared with the theoretical volumetric flow of the same dosing operation. This way it easy to visualize the influence of the material flow behaviour and how it could be adjusted the filling coefficient used in the calculation of the theoretical volumetric flow.

mmeybodi@aut.ac.ir

IV. CONCLUSIONS AND FUTURE DIRECTIONS

As example of the application of this experimental dosing stand, in figure 4 was presented a dosing batch diagram that was executed with the standard procedure of dosing. As it can be seen the time to execute this batch was mostly spent on the raw dosing stage.

For comparison purpose the automatic method of dosing procedure (fig. 5) was also tested on the same batch and material and it was observed that the time allocated for the fine dosing stage was almost 2 times greater but the changing in the dosing regime was much more smoother ensuring this way a better control of the material flow.

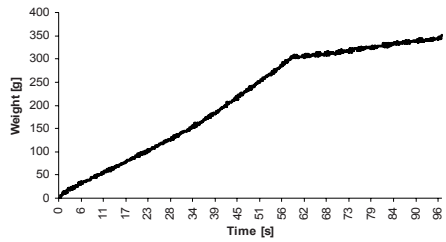


Fig.4. Example of a dosing sample made at 350g for wheat bran using the standard method of dosing.

The developed experimental and teaching stand is able to present the impact of the working parameters upon the final result of the dosing process and to help the students to experiment interactively with the dosing stand by setting up different values of the working parameters and to analyze the data files of the final result.

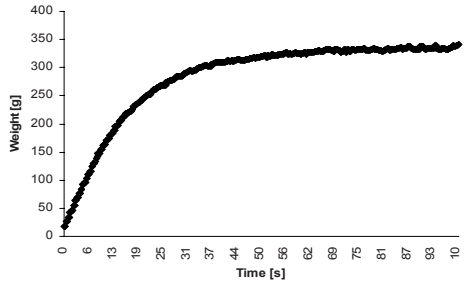


Fig.5. Example of a dosing sample made at 350g using the automatic method of dosing.

The automatic control interface of the realized stand can offer good monitoring of the dosing parameters and can help in the understanding of the impact of the material flow behavior on the disturbances in the dosing operation with great significance for the volumetric dosing procedure.

Future directions for development of the dosing stand will be conducted in the direction of improving the dosing system to be self aware of the working parameters that influence the dosing process and based on these data the system will prescribe the value of the working parameters for the dosing operation in such way that it will achieve the highest precision and the shortest time to batch the material.

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mmeybodi@aut.ac.ir

Test Harness Environment for Embedded Java Applications

Olga Korolyova
st. Sedova, 12
192019, Saint-Petersburg
Russia
Olga.Korolyova@motorola.com
Andrey Pakhomov
st. Sedova, 12
192019, Saint-Petersburg
Russia
Andrey.Pakhomov@motorola.com

ABSTRACT

There are many devices with java embedded platform that allow executing generic Java applications. Some of the examples are smart phones, PDAs, set-top boxes, etc. Developers can create and users can download such applications to their devices. The number of embedded applications increases each year and developers should adapt efficient software development techniques in order to move their products to market in time and with high reliability level. There are currently so many software development frameworks and techniques for standalone or server applications that embedded software developers often miss out on them. One of the most important to follow practice is testing. The authors have developed several products for PC in Java where testing was formally defined and automated with JUnit. That experience demonstrated a value of regular test runs for product reliability and development stability.

This paper is devoted to the testing process of embedded Java application on target devices using JUnit based test cases. The test process described in this article includes test cases creation on personal computer and their execution on target platform via client-server interconnection using special techniques developed specifically for this purpose.

INTRODUCTION

Testing is one of the most difficult and resource consuming phases of any project. It has very important goal - a guarantee that a product is of a required quality. A lot of money is spent on testing technologies and tools. Each development area has its own specifics as a result testing technologies and tools vary for different purposes. In this article the authors take a look on testing of embedded applications.

Embedded application is a specifically designed application aimed at a target electronic device. Embedded applications are developed according to the device environment, platform, and available resources. Testing process for such applications is based on device specifics. The authors describe several ways to test an embedded application as well as advantages and disadvantages of each approach.

DEVELOPMENT ENVIRONMENT

Embedded application resides on a target device. There is a common practice to use a special simulator during development stage of a project. Simulator can be loaded on the development machine, for example a personal computer. However testing requires an application being tested to be installed on real platform to ensure that it works correctly. That is why a development system for embedded applications can be thought of as a distributed system with two machines. At its minimum it is a development computer and a target device. The simple development cycle includes development and creation of executable file on development machine, plus loading and execution the file on the target machine.

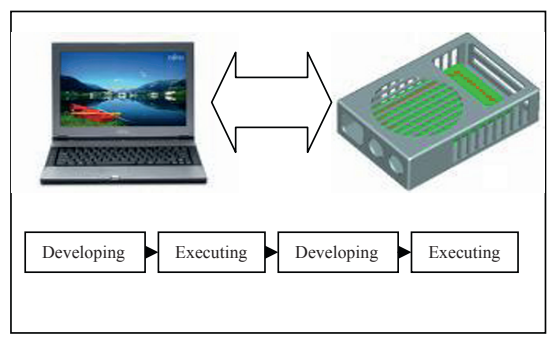


Fig. 1. Development Process

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 396–399.
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SIMPLE APPROACH

One of common approaches to embedded applications development is to use a specialized software development toolkit on Personal Computers to code and compile the application, and then upload it to the target device for testing and debugging. One of the obvious ways to test an application on a target platform is to upload and execute the test suite on the device. It relates to automated tests for the embedded applications.

Automated tests for embedded applications can cover the following functionality:

- Any kinds of protocols
- Standalone application modules, e.g. business logic, data storage.
- Public Interfaces between applications modules
- User interactions for graphical elements if application has "designed for test" architecture and allows simulating user events.

Depending on the device specifics test suite can be loaded in different ways. It can be a part of applications if the application has option to be configured in testing mode (**Fig. 3**). Another way is to load a test suite as a standalone application which is granted access to data from the product being tested (**Fig. 2**).

Uploading an entire test suite is useful for test cycles with a large number of test cases to be executed or some acceptance criteria to be checked. However it can be rather complex if testers need to run only a few test cases or for testing during development when the test cases are loaded and executed quite frequently. This approach requires application and test suite to be loaded on the device and executed each time the change is made.

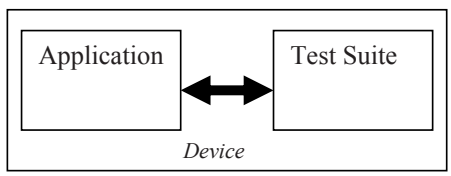


Fig. 2. Standalone Test Suite

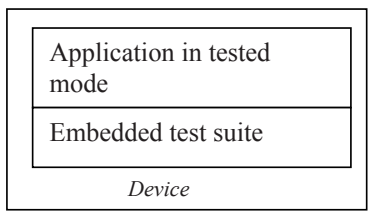


Fig. 3. Embedded Test Suite

Given that overhead time ($T_{overhead}$) is the time to compile and load the tested application on the device's platform. Given the time to compile and load test case ($T_{test_case_overhead}$) is a sum of the overhead time and the time required to compile and load the test itself (T_{test_case}).

$$T_{test_case_overhead} = T_{overhead} + T_{test_case}.$$

The goal is to reduce $T_{overhead}$ to a minimum for frequent test case executions. Theoretically the minimum value shall be zero. The graph **Fig. 4** demonstrates the desired tendency.

One way to solve the problem is to spend $T_{overhead}$ once on test preparation and then execute only required test cases in already preloaded environment.

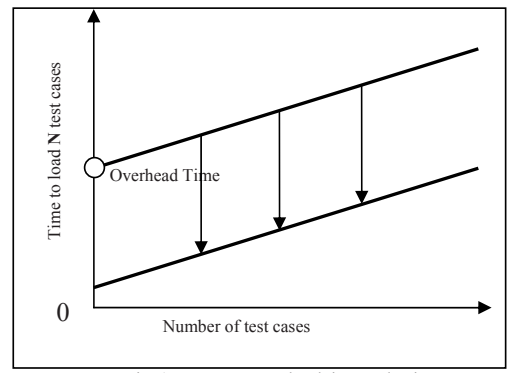


Fig. 4. Test cases overhead time evaluation

DISTRIBUTED APPROACH

The idea of speeding the test cases loading up is based on client-server interconnection between the target platform and the computer where development is done. There should be a test agent for the target platform with the following list of common functions:

- It is loaded once with the tested application on the target platform
- It supports any kind of protocol to have ability of getting test cases files via network.
- It loads test cases files in runtime and save the test result somewhere.

There should be a special test client on development computer with the following common functions:

- Supporting the same network protocol
- Sending test cases to the target device

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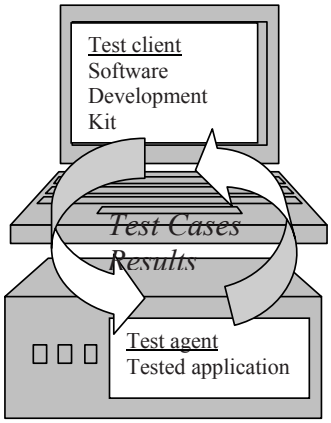


Fig. 5. Client-Server Interconnection

The above described system requires development of additional client, server and a protocol parts. Their common function is to enable the upload of necessary components to the target platform just once and only to fast reload test cases over and over during the run time. The common scenario can be as follows:

- Preparation stage: load the necessary environment that also includes the application being tested to the target device
- Execution stage: compile the file in the development area and send it via protocol to environment already loaded. Working in this stage the tester does not need to spend $T_{overhead}$ time, but only the time necessary to run test case itself.

However it will be problematic to apply the described system for loading the large numbers of tests. It is dependent on the protocol realization and hardware capabilities. Combining different methods can actually prove more effective testing for embedded applications.

IMPLEMENTATION

The authors apply the distributed approach idea in digital TV area for Java applications loaded on set-top box devices with Open Cable Applications Platform (OCAP). There are two main areas in the implemented system:

- Personal Computer (PC) is used to develop the test case code and run them via special client on the target platform. The client is implemented as a plug-in for Software Development Kit used for code developing – Eclipse. It allows sending the compiled test cases to set-top right from the place where the code is being developed and compiled.
- Set-top box is used to execute test cases on previously loaded OCAP stack and application via special test agent (server). Server is also OCAP based application which is loaded along with tested application's classes on set-top and can connect to the client from PC.

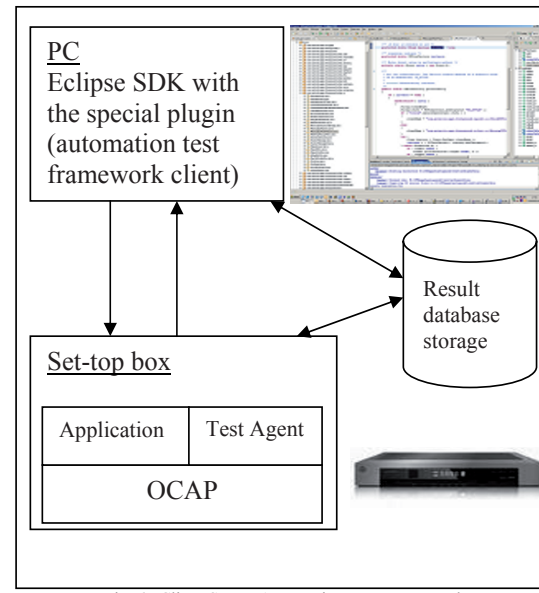


Fig. 6. Client-Server Automation Test Framework

A special protocol was developed that allows sending compiled classes of test cases to set-top via network. The server main role is to load a test tool which in turn executes test cases using Java Class Loader mechanism in the same Java machine. This approach allows updating classes during runtime without having to restart the OCAP stack. The authors use freeware popular java test tool JUnit for test cases development.

Thus test framework for the system just described, includes tree modules:

- Test Platform - the test tool based on JUnit with several extended useful features such as powerful logging of the results into SQL data base and additional assert method. The test platform is a Java tool that does not depend on any underlying platform.
- Test Client – Eclipse plugin which connects the development environment and a set-top box.
- Test Agent – is OCAP based application executed on the set-top that can transfer test cases from the development environment via network and execute them using Test Platform tool.

Test Platform tool can be used for any platform that has Java SDK installed on it. In case of Simple approach the whole test suite is executed on the device using only Test Platform. For the second approach Test Client and Test Agent are added to comprise the test system.

mmeybodi@aut.ac.ir

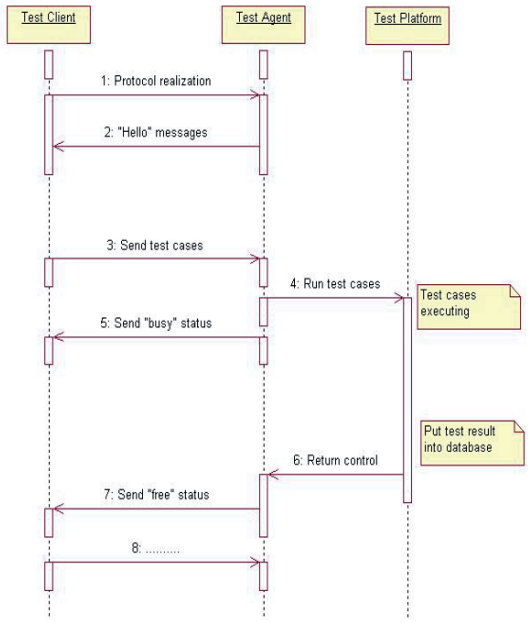


Fig. 7 Actions sequence for Disctibuted Approach.

The described distributed approach allows the project team to avoid frequent restarts of the OCAP platform for each test execution. The execution time for a single test case is cut by half. Average $T_{overhead}$ for described system is about 1.5 - 2 minutes. Average time of executing simple test case scenario without overhead is about 1 minute. For frequent rerun of test cases $T_{overhead}$ time is considerable.

This approach is also useful for unit testing which is conducted by a developer. There is a common practice where developer creates a small unit test for one single feature that he or she changes during development.

However, for regression test suite all test cases can be grouped into one test suite and just loaded on a set-top. This method of test execution should be chosen according to the current project needs to make the process effective.

CONCLUSION

Both approaches complement each other. Distributed approach shows its advantages specifically during the test case development stage. The simple approach can be more powerful on the test stage requiring all test cases to be executed.

Experiments show that the distributed approach has its powerful effect only for quantity of test cases less than some practical number. This number depends on the system's specifics. It can be somewhere in hundreds or in thousands. This approach may be ineffective for a large test case number due to network congestion. The area of effectiveness for the distributed approach is illustrated on the graph:

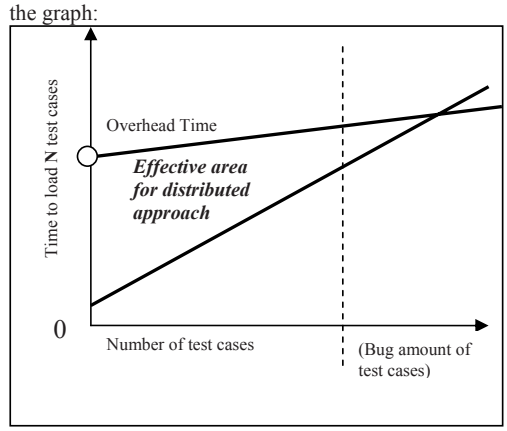


Fig. 8. A tendency for huge amount of test cases.

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mmeybodi@aut.ac.ir

Study Management and Allocation of Exercise Classes for Large Lectures at TU Berlin

Sabina Jeschke
University of Stuttgart,
Center for Information Technologies - RUS
70553 Stuttgart, Germany
sabina.jeschke@iits.uni-stuttgart.de

Robert Luce, Nicole Natho, Olivier Pfeiffer, Erhard Zorn
Berlin University of Technology
Department of Mathematics and Natural Sciences
10623 Berlin, Germany
{luce, natho, pfeiffer, erhard}@math.tu-berlin.de

***Abstract*- At TU Berlin the number of students in major classes for students in their first semesters easily exceeds 2.000 in a single course (Analysis I for engineering students, for example). Due to this large number of students, simple organizational duties such as assigning exercise courses to students or tracking admission criteria for final exams become challenging. We present an environment – the "MOSESKONTO" – that helps finding an optimal (in respect to student wishes) assignment into exercise groups and provides means for tracking and managing exam registration. Based on the data acquired in the summer term 2005, already 50% of all bachelor exams were managed through the MOSESKONTO at TU Berlin.**

I. INTRODUCTION

A common problem for big universities, that do not provide fixed timetables for their students, is the distribution of students into small exercise groups (so-called "tutorials") accompanying the lectures. That is, many students with individual time constraints have to be matched to one or more tutorials on different time slots. Since the individual constraints are not known a priori, letting the students make ratings (often called "wishes" here) and finding a matching in that manner that as much as possible students are mapped on their highest ratings seems to be an appropriate procedure.

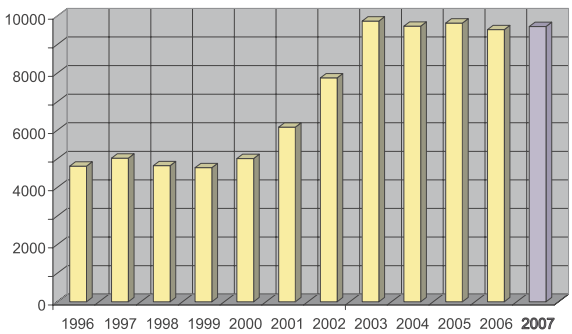


Fig. 1. Number of students attending math-service lectures

II. ORGANIZATION OF CLASSES AT TU BERLIN

One of the major challenges facing universities is the organization of the study supporting processes, especially in freshmen courses [1]. With about 30.000 students, TU Berlin is among the largest (counting students) technical universities in Germany. As a service for other faculties, the institute of mathematics is in charge of the mathematical education of most students, independent of their actual course of studies, making it the biggest "service provider" of the university. Since a major reorganization of the math-service five years ago, every year, 9.000 to 10.000 (cf. Fig. 1) students from 18 different courses of studies are taught courses in one of the six "math-service" engineering modules (Analysis I–III, Differential Equations, Integral Transformations & Partial Differential Equations, Linear Algebra). The largest module is the freshmen course in Analysis with a total count of more than 2.200 students per semester.

The modules are organized as follows: In order to guarantee lecture class sizes of less than 250 attendees, multiple lectures are held in parallel. The lecturers of the individual lecture classes take care of presenting the same mathematical material to all attendees. In addition to lecture classes, all students have to solve the same exercises as homework and, in the case of sufficiently good homework score are admitted to take the written examination at the end of the semester. Students also are eligible to attend a small-sized exercise class where the material of the lectures is manifested.

The following list summarizes the administrational duties for performing math-service:

- Assign all math-service students to exercise classes
- Manage homework scores for admission to final examinations and course credits
- Management of student registration for examinations
- Inform students about examination scores
- Collect and submit examination scores to the central office of examination.

Although all of the above tasks are typical administrational duties for student management at universities, the large course sizes make them very time-consuming and labor-intensive. This is especially true for the assignment into exercise groups for every module: All students have to be assigned to small (meaning total sizes of 15 to 30 students each) groups such that assignments do neither conflict with each other nor conflict with the individual schedules of the students while respecting certain capacity restrictions. But, the large course sizes not only present difficulties; they imply a great opportunity of rationalization in the student-administration.

Against this background the development of MOSESKONTO[1]

[1] Moses as acronym for Mobile Services for Students and Konto as the German word for account

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[2,3] (cf. Fig. 3 for a screenshot) began in 2002 and was initially deployed and used since 2003 for all courses within the math-service modules described above. Since the winter term 2005/6, the assignment into exercise classes and management of exams has been extended to cover further courses, even across different departments. More courses are expected to follow in the upcoming winter term 2007/8.

III. ASSIGNMENT INTO EXERCISE CLASSES

Every student who attends a course in one of the math-service modules is eligible to attend an exercise class. The number of attendees for a particular course is not known until the semester starts, as the enrollment process does not end until then. The students do not know their complete schedule until this time either, and the variety (with respect to course of study) of students attending math-service courses implies a great variety in individual schedules. These two facts make it impossible to fix a set of dates for exercise classes in advance. Instead, one is forced to find dates for these classes in the first week of a new semester, by taking into account all students' timetables.

Until the winter term of 2002/3, the assignment of students into exercise classes was performed independently for every math-service module. The procedure required all students of a particular module (up to 1.000 people at that time) to gather in the main lecture hall to receive their exercise class dates. The students were numbered and subsequently drawn by lot to choose their most preferred date from the remaining dates in the global pool of exercise classes. Of course, this procedure did not guarantee that every student received his most preferred date, but it did ensure that the assignment of a whole course is feasible within 90 min.

The integration of additional courses (and thus increasing the number of students to be administrated by math-service) invalidated the above assumption about the feasibility of the assignment method. In fact, the last time the above method was applied, it took several hours and forced more than 2.000 students to be physically present in a completely overcrowded main lecture hall construed for 1.200 students (cf. Fig. 2).

Since this development in the number of attendees was foreseeable, the development of a web-based registration procedure (cf. Fig. 3) began in the spring of 2002; the new method has been used since the summer term of 2003.

The major goals of the new procedure were:

- Gather early information on the expected number of students for every module
- Take into account the student's individual schedules by collecting their "wishes" for dates
- Distribute students as even as possible among all exercise classes of every module
- Assign students such that no date conflict arises for students that attend courses in more than one module.

It was not possible (for various reasons) to access the personal data of the students from the central office of enrollment. Thus, to realize a procedure that respects the requirements above, students would need to register at MOSESKONTO and create a personal account. But, as a side effect, the same personal data can be used to manage the final exams. The latter is a great improvement over the established way of registering for an exam: students had to register at the central office of examination with a paper form, from which a press copy of their registration form is sent to the department of mathematics, where these copies are entered in an excel sheet. Of course, numerous transcription errors are produced that way.



Fig. 2. Main lecture hall during the assignment of exercise classes at the beginning of Winter Term 2001

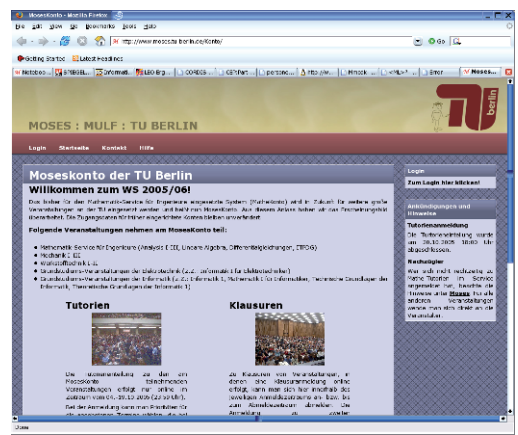


Fig. 3. Web-interface of the MOSESKONTO

All of the above requirements could be easily met by means of an assignment procedure operating on a first-come-first-served basis. But it would favor those students over others, who receive their certificate of enrollment earlier. And from a technical point of view, it would concentrate the registration traffic on a very short time span, which means that the system probably would not scale well for increasing numbers of students. This motivated our decision for a global optimization method: Over a given time span, say, two weeks, students have the opportunity to chose their personal priorities from a range of possible dates for every math-service module they would

mmeybodi@aut.ac.ir

like to attend courses in. All students will choose their favorite dates using their MOSESKONTO account, and can revise their choices at any time. After the registration time span, the collected data is used to compute an assignment that is optimal in respect to all student's priorized wishes.

A. Student Groups

Often, students have organized themselves into groups of two or three to work collaboratively on their homework, for example. It is desirable, although not essential, to let all group members attend the same exercise class. MOSESKONTO offers the opportunity to register for an exercise class as a group, which implies that all group members have to choose the same priorities for the available exercise class dates. The functionality to mange groups (change groups, step back, etc.) is provided through MOSESKONTO as well. These groups are not formulated as constraints in the global optimization problem, but some care is taken to respect these wishes for groups if possible.

IV. THE GLOBAL OPTIMIZATION STEP

The optimization step involves the computation of all assignments of students into exercise classes, such that room- and teaching-staff capacities are respected and the computed solution is optimal in respect to the given priorization of dates. The problem admits a formulation as a constrained minimum-cost-flow network problem [4-8]. An example of this network is depicted in Fig. 4. The resulting integer linear program finds a solution in acceptable time, that is, less than one minute for the largest instances seen so far on a recent machine. The data from MOSESKONTO is accessed and preprocessed by the software TUTOP [9], which also formulates the integer program that is then to be solved by the commercial software CPLEX [10].

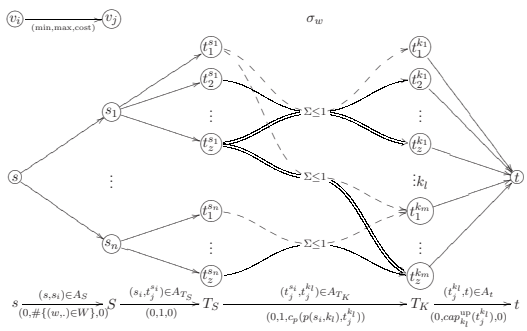


Fig. 4 Network for several courses (The boundaries and costs for all edges are denoted symbolically in the lower row).

V. EVALUATION OF THE COMPUTED ASSIGNMENTS

The quality of the solutions achieved by the method described above is generally very good, even under rather tight capacity restrictions. As an example the results from the assignments in the summer term 2005 are discussed. In total, 4.198 "seats" have been assigned, where 4.392 had been available.

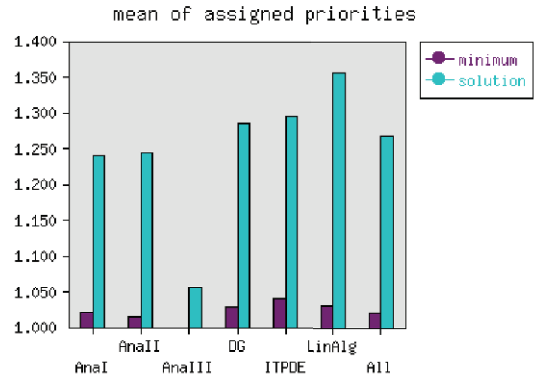


Fig. 5 Quality for each module (left), overall quality (right)

Fig. 5 breaks down the above numbers into the six modules mentioned in chapter 2.

It is worth noting that the good fill rates could not have been achieved without a preliminary analysis and allocation of available resources during the registration time span. By doing so, teaching staff can be moved from one module to another and additional room resources can be acquired ahead of time.

During the registration time span, students had to prioritize five dates for every module they would like to attend exercise classes in. The mean priority of the assigned exercise class dates was 1.27 and every student received a date among his prioritized dates.

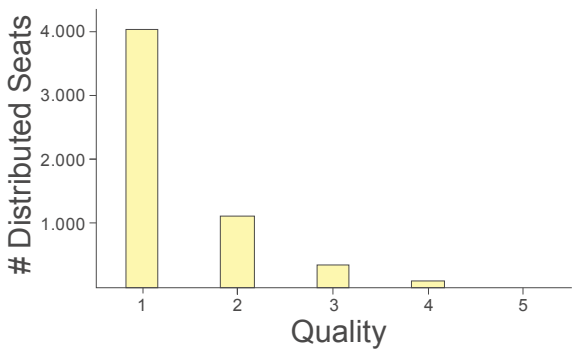


Fig. 6 Quality for all Modules

An additional measure of quality can be derived from the "mean of assigned priorities. For every module, it shows the theoretically possible best mean (between 1 and 1.05) of assigned priorities and the achieved mean (between 1.05 and 1.35). The first is defined by the mean of an optimal set of assignments when an infinite number of rooms and teaching staff members would be available. Even in that case, the mean is greater than 1, since students may choose the same date as first priorities for different modules.

VI. ADMINISTRATION OF EXAMINATIONS

As a rule, each student participating in the service courses "mathematics for engineers" has to pass a written final exam

mmeybodi@aut.ac.ir

(consisting of up to three separate written tests) for each module. As a result, up to 8.000 written exams have to be handled, creating a substantial administrative overhead. The efficient organization of such large exams requires punctual registration on the part of the participating students. The results have to be published and forwarded to the central office of examinations of the corresponding departments, possibly followed by final corrections based on students' searching of the exam. Finally, the results have to be processed statistically to provide the responsible deans with information concerning the success of the courses.

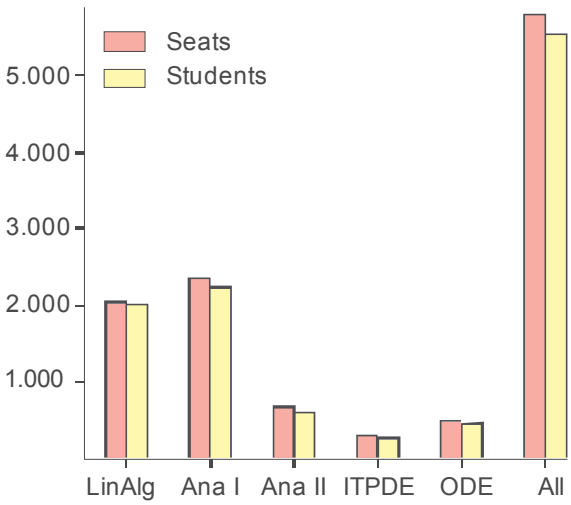


Fig. 7 Numbers of places for different modules vs. numbers of required seats.

To satisfy the regulations imposed by the different courses of studies it is necessary to hold up to three different (though identical in content) exams. As a result, the students feel insecure which exam they have to register for. To alleviate this problem, the students are only presented with the appropriate exam for their particular course of studies when registering for the final exam for a given module. Registration for final exams for compulsory optional subjects and exams governed by older or more "exotic" examination regulations has to be done in person at the service center, which also has access to the examination administration of the system.

When "creating" an exam in the database, the registration and deregistration periods have to be specified. Students have to (de-)register during that specified period only, deregistering for (officially certified) medical reasons being the only exception being handled exclusively by the central office of examinations.

Information for each exam is available for download by the service center or other authorized staff in the form of a zip-file containing the following:

- A list **of all students registered for this exam**, including their personal data and the results of the exam (in csv-format)
- **Separate lists for each course of studies**, containing the names and personal data of each student registered for the exam to be forwarded to the central office of examinations (LaTeX -Format)
- A **complete list of all registered students** including personal data for proof of identity during the exam (LaTeX -Format)
- **Separate lists for each course** of studies, containing the **names, personal data** and **exam score** of each student registered for the exam to be forwarded to the central office of examinations (LaTeX -Format)
- A **complete statistic** including a graphical representation **of the results** (LaTeX -Format)

The lists of registered students forwarded to the central office of examinations replace the more traditional registration forms handed in by the students in person. Similarly, the lists containing the result, once signed by the professor, replace the minutes of the examination previously required for each student separately.

The complete csv-format list of participating student is used as the basis for assigning the students to the rooms available for the examination and to determine the needed capacity and thus required rooms in the first place.

VII. Administration of Homework

Most courses of study require mandatory homework as a prerequisite for admission to the exams. However, some few courses, that have a large number of students though, form an exemption from this rule. As a result, homework is a prerequisite for approximately fifty percent of all students. The homework-related criteria that are to be met for admission to the exams are currently dependent on both the module and the professor teaching it. In consequence, it is necessary to store the criteria (as a boolean) for each module and each semester separately.

Authorized staff can access the list of course participants at the end of the semester to add if the student met the homework-related criteria or not.

The system does not check if the homework-related criteria are met during the online registration for the exam as the last homework assignments are regularly neither handed in nor graded by the time the registration period has expired. The registration lists, however, contain the information about which students met the criteria, enabling the service center to deregister students if appropriate.

VIII. Access Rights Management

Typically, the users of the system fall into one of the following groups of people requiring fundamentally differing access right that can even vary between departments:

- **Students**, as a rule, are granted access to their own personal data and nothing else (exception: courses allowing team work, see section III.A). They are given write-access for their own data and for registering for exams or exercise classes, otherwise read-access only.
- The **Administrator** is given access to all information; he is provided with additional, special rights, such as the creation of new modules.
- **Employees of the Service Center** are usually

mmeybodi@aut.ac.ir

responsible for all communication with the central office of examinations and is the central contact for all students.
- **Teaching Assistants** are often responsible for entering the results of exams and similar tasks.
- **Tutors** will input if the homework-related criteria are met and have access to the personal data of their students.

The growing interest of other departments to use the MOSESKONTO for the registration for their own exercise classes, examination and student administration outside the mathematical service modules requires an expansion of the access right management to facilitate the independent administration of their students. These changes have to account for different access right requirements for the above mentioned user groups.

As a solution, we have implemented a hierarchical access rights management system mirroring that of UNIX. All reading or writing rights for the different types of information (e.g. access to the students' personal data or to their examination results) are treated as a single, independent resource. Passing these resources (reading or writing) is treated as a third type of resource. User groups (e.g. teaching assistants) can be created and are defined by their associated access rights. The owner of a group (either because he created it or it was associated with him by default) has the right to add or remove members of the group or grant access rights to group members within the limits of his own rights. Students are outside this access rights management, as their rights do not have to be defined on a per-module basis. The right to register for an exam for example can be managed through the use of a registration time period.

IX. EXPERIENCES WITH THE SYSTEM

The MOSESKONTO has been deployed successfully at the TU Berlin for three years. The registration for exercise classes for the mathematical service modules would be impossible without the online registration given the steadily increasing numbers of participating students each semester. The online registration spares both the students and the teachers from time-consuming in-situ registration while better addressing the needs of students. The approach of a global optimization implemented in the system requires a significant amount of effort in the mathematical modeling of the problem but provides the following, significant advantages:
- **conflict-free assignment** of exercise classes across several, different modules
- optimal **adaptation** to the **wishes** of the **students**
- **optimal use** of existing **room resources**
- **optimal use** of existing **staff resources**
- **instantaneous information** concerning number of participating students

The deployment of the MOSESKONTO to administrate exams has been equally successful. Without the use of online registration it would have been impossible to keep up with the vastly increasing number of students in the mathematics service courses for engineers (almost doubled in the last few years). The online registration has saved students hours of waiting commonly associated with the registration for an exam.

Starting with the winter semester 2005/6 the use of the MOSESKONTO has been extended to cover modules beyond mathematical service courses. New modules administrated through the system include electrical engineering, modules in the computer sciences, mechanics and the material sciences. For the summer semester 2006 standard mathematics courses and the service module in physics for engineers courses will be added to the list of modules included in the MOSESKONTO. In consequence, the MOSESKONTO will administer the exercise class administration for the largest and most important service courses for engineers. The conflict-free assignment of exercise courses for these important exercise classes represents a significant improvement in the course administration.

Next to the mathematical service courses, "physics for engineers" and "mechanics" are the largest single modules offered at the TU Berlin. Starting with the summer semester 2006 the MOSESKONTO will be extended to include the examination registration and administration of these courses as well, following the coordination of the transition with the central office of examinations.

X. OUTLOOK

One desirable future feature of the system would be a direct, automatic exchange of data, in particular, of the registrations for and results of examinations with the central office of examinations. This exchange could be realized in the form of the transfer of data in an XML-format, replacing the current, error-prone, manual transfer of data. Preliminary efforts of coordination have shown the general willingness of the central office of examinations to participate. However, certain adaptations to their software are required and are not yet implemented.

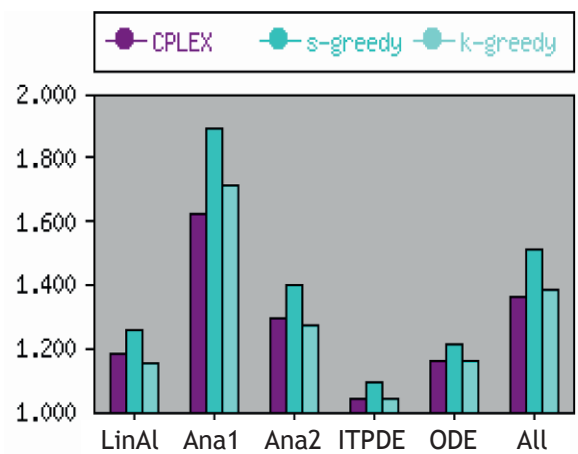


Fig. 8 Comparison of the results currently achieved using CPLEX [11] and our own solver

On the technical side we are working on our own solver in order to be independent of proprietary software and thus allow for the employment of the MOSESKONTO at other universities

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at no charge (cf. Fig. 8 for some preliminary results of our own implementation.

In addition to the inclusion of minor, new features, such as the ability to store the results of weekly assignments separately, that have resulted from the requirements of other departments, the MOSESKONTO is currently undergoing a redesign of the optimal allocation of exercise courses. The aim of the optimization lies in a single-pass allocation including the corresponding room assignment. This has to include additional constraints such as preferences for certain specific rooms expressed for a given module that are hard to quantify within the mathematical model.

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mmeybodi@aut.ac.ir

The Changing Concept of Digital Divide

O. Mäkinen
PhD, University of Vaasa
P.O. Box 700
FI-65101 Vaasa, FINLAND
olli.makinen@uwasa.fi

J. Naarmala
Vaasan Läänin Puhelin Oy
P.O. Box 59
FI-65100 Vaasa, FINLAND
jyri.naarmala@iki.fi

Abstract – **The concept of digital divide is studied in this paper. The authors show that the concept of digital divide has got a new meaning in the Nordic countries. The stress is no more an factors like age, costs, family structure, income, geography, rural and regional factors, religion and so on, but the main cause of digital divide is the lacking skills in using the ICT.**

Keywords – Digital Divide, Change, Society, ICT, Conceptual Analysis

I. INTRODUCTION

Since the introduction of the first visions concerning global information society (Yoneji Masuda, Manuel Castells, Tom Stonier) the threat to unequal access for information has been brought up by skeptic voices. Later the concept was given a name, Digital Divide. The significance of this concept has not vanished, but the inner meaning of the concept is starting to be outdated and is in a need for thorough revision. The main goal of this paper is to present existing definitions of digital divide and to show how the concept should be updated. As such, this paper exercises approach commonly used in conceptual analytical research [1] and thus is mostly a theoretical paper.

We are, however, going to test our main thesis that in the Western "capitalistic" countries the digital divide is closely linked with the know-how in information technology, with the teleinformatic skills or technical ability. Therefore an empirical research made among students in Vaasa Polytechnic (at present Vaasa University of Applied Sciences) between 2004 and 2007 is preliminary presented in this paper.

According to lexical definition the digital divide refers to: *"[---] a division between those in favour of the extensive use of digital technology (esp. computers) and those against it; (b) (now the usual sense) the gulf between those who have ready access to current digital technology (esp. computers and the Internet) and those who do not; (also) the perceived social or educational inequality resulting from this [---]*" [2] The concept is used here to refer in the first place to unequal access to computers and computer networks. Authors argue that the original definition of digital divide does need a revision, because the nature of division is no longer simply based on the division between those who favor technology and those who do not, nor on the access to digital technology.

According to Economist Intelligence Unit e-readiness ranking [3] a critical shift is occurring in the social fabric of countries: as governments and enterprises increasingly migrate services online, those without reliable Internet access are in danger of being disenfranchised, e.g. the concrete risk for digital divide is present. Due to this both public- and private-sector organizations have spent considerable time and money on trying to get *economically disadvantaged* communities online. Increasingly, these attempts are spreading to the *socially disadvantaged* as well. According to report [4] senior-citizen access has been a particular focus for developed countries, where some 20,000 senior citizens are estimated to have been trained through various initiatives. EIU report (2007) seems to combine concepts of economical and social disadvantages as digital divide, whereas technical ability is not seen as a key factor, like in OED definition.

Norris [5] raises into focus a fact that the global digital divide is substantial and has been growing during the first decade of the internet age. Payton states that (2003, p. 91), while the efforts to eliminate the digital divide are valuable, public policymakers must also seek a way to improve the social network that will help the digital divide to resolve itself.

According to Norris [6] digital divide has many faces. Norris asks if the fast and revolutionary development of information technology will reinforce or erode the gap between information-rich and poor nations, if it will exacerbate or reduce social divisions within different countries or strengthen representative democracy or, on the contrary, buttress the power of established interests, both the political and economical structures. So, the question is whether information technology is a restructuring or the maintaining force.

It is said that the Internet places different demands on the user than the medium of television-access and its use requires both cognitive ability and technical skills [7] [8]. Most Finnish and Swedish people have "reasonable" access to the Internet. There is, however, a constant amount of people who voluntarily or involuntarily have chosen to stay outside the information networks. What is the reason for that? It can't be said that in the rich Nordic countries the cause of digital divide could be only ethnical or depend on factors like age, costs, family structure,

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 406–409.
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income, geography, rural and regional factors, religion, education and so on.

Some people have voluntarily decided to stay outside the information networks. Therefore we can't speak of digital divide, because it is always possible to presuppose that the people are able to make a connection to the Net whenever they want. This is, however, a false conclusion or at least a generalization. The real reason may be any of the above-mentioned. Maybe people are not able to use the Internet because of the lack of technical skills. They could have possibilities to acquire education or guidance. Why don't they do it? It is possible that they are ignorant – they are not interested in the contents of the Internet. Or they estimate that the efforts to catch up the skills are too laborious.

We are going to emphasize two contradictory hypotheses tied up with digital divide in two Nordic counties, Finland and Sweden. Firstly, educational qualifications are no longer important in predicting Internet access. The higher qualified the individual, the more likely that he is to have Internet access at home – this was a fact before [9]. It has, however, changed. Secondly, we will stress the connection between the use of the Internet and the technical skills. Those without information literary education are thus more likely to be in a need of training and support facilities to enhance computer literacy and IT skills and knowledge. And thirdly, we will study the reason why a great amount of people deliberately and voluntarily want to stay outside the information networks. We are speaking of the Nordic countries and by this we mean Finland and Sweden which are very similar as far as the IT technology and infrastructure are concerned. But first of all, we are going to try to see what kind of benefits the Internet has to the civil society and democracy. Why is the common access to the Internet so valuable?

II INTERNET AND DEMOCRACY

Many pioneers of the information age had high hopes when the Internet was introduced. But maybe the Internet didn't fulfill those expectations. People were talking about increased democracy and freedom, better possibilities in all social participation and communication and so forth, basically about the democratic values. Jürgen Habermas says in his theory of discourse ethics that there is a communicative void in the society. The more people and institutions communicate in a society, the more efficiently democracy is working. [10] The Internet should fill this communicative void. This also means that the Internet could be socially valuable – a positive value.

But the Internet is constantly changing; it is a dynamic communication environment. According to Habermas the bourgeoisie, when it had taken the power, immediately began to work up the public sphere, where communication takes place, in the favor of its own interests. There prevails only one truth in that kind of society. The Internet, on the contrary, represents pluralism, competition between different opinions and genuine free public debate [11]. Economical interest, commercialism and the commercial media threaten free communication. According to Habermas these do not belong to the area of free communication, nor do the administrative organizations. In the early days of the Internet there was no commercialism and as little administration as possible. Lee Salter, a Habermas researcher, says that the Internet grows all the time apart from those ideals of free communication which were so typical of it in the beginning. The governments use the Internet more and more for administrative and propagandistic aims, and they are trying to use the Internet as a means to control the citizens. The ideal of Internet communication was interactivity in the beginning, whereas communication has recently become more and more one-sided or non-communicative. [12]

Deborah G. Johnson claims that commercial interests have increased their influence on the development of the Internet. This is based on the fact that free market forces have realized that the Internet is an important and efficient tool and media [13] and have taken over it.

Democracy was one of the great ideals in the pioneering times of the Internet – as stated for instance in Yoneji Masuda and the Computopia in 1972 [14]. Like other positive values it may be described as an impetus or a driving force that put the Internet's development in motion. But as it is with all the ideals and beautiful values, they do not flourish in reality. Many of the NSMs (New social movements) make use of the Internet when communicating. Internet is cheap, fast, interactive and offers possibilities to anonymity. But these movements that operate underground or outside the control of the society are often organizationally antidemocratic. [15] There is always risk for the fall of free, progressive forces and the victory of institutionalization and stagnation.

The faster the Internet and ICT are growing and developing, the better has become the methods of controlling the citizens. Panopticon, Michel Foucault's all-embracing metaphor telling about and describing the official horror and terror, has finally been realized [16]. At the same time as the Internet makes the communication between individuals run smoothly, it gives the public administration and terrorists (hackers etc.) a comparable and efficient tool to supervise and sort people, to invade citizens' privacy. With the assistance of the figure and face recognition it is possible to pick up persons from an anonymous mass and build up their virtual identities that has little to do with the real personae. Is the effective way of controlling people valuable in one way or the other? Of course, if we think of the public administration, bureaucracy and all the overseeing authorities (the police, the customs, security services or tax authorities), the efficient monitoring is a useful phenomenon. [17] The question is about the balance between privacy and thrust. The more the public takes over the area of personal privacy, the more the citizens feel anxious and defend against the intrusion [18].

mmeybodi@aut.ac.ir

III DIGITAL DIVIDES ARE LEVELING OUT

In a recent review by the Statistics Finland Juha Nurmela et al. [19] states that 70 percent of the Finnish households have the Internet connection and 80 percent of the Finnish people use the Internet regularly. There is no great diversity by gender in the Internet use, only the heavy users are without exception men. Also in Sweden male and female are using the Internet equally [20] It seems that the better education people have the more they use the Internet. Almost 100 percent of the students use the Internet in both countries and the same concerns employed persons. This means that the Internet is more and more a tool. The pensioners are also beginning to use the Internet – the proposition of elder Internet users is growing fast.

When the use of the Internet is most common among students and active employees, the accession to the Internet has been widespread – the Internet is open for all. The fees are very cheap and especially in Sweden the broadband network extends to every household. What separates citizens is the quality of the Internet connections. Just now mobile network connections are becoming more and more common and this new technology isn't very cheap.

IV THE GAP DEPENDS ON THE SKILLS

Digital divide in the Nordic countries is obviously a consequence of computer and Internet skills. In Finland both computer and Internet skills have continued to improve in recent years [21]. The proportion of those who master the use of Internet browser and e-mail has exploded over the past ten years. It is a strong possibility that the use and the skills of not so user-friendly software is not going to rise very fast.

It is very easy to provide proof that information literary skills are easy to teach and assimilate. A good example of that is the course in information literacy that has been developed in the Tritonia Academic Library at University of Vaasa [22]. The students' information retrieval skills (Boolean logic, truncation, use of keywords etc.) developed notably after this course [23].

Actually it was not very surprising that the students learned without any difficulty to use the right terms in information search. And it was natural that they first used the wrong way in searching, i.e. the natural language of free text, because it is the way you search in Google. [24]

That the technical skills are so crucial reasons of digital divide or information technological marginalization has been proved in a study made among students in Vaasa Polytechnic (at present Vaasa University of Applied Sciences) between 2004 and 2007. The students, who were mostly studying IT or electrical engineering were asked to write an essay. They could choose between different topics (Cybersex, Netiquette etc.). We are interested in those students who wrote an essay on a topic of the digital divide. The title of that essay was "What is the most discriminating factor in the use of the Internet? The text analysis of the data is still going on, but as a preliminary result it can be said that almost 80 percent of the students considered that digital divide in Finland originates from the lack of computer and Internet skills. They also saw a connection between social discrimination and the use of the Internet: a great deal of the public service is being virtual and moving to the Net.

V THE NON-USERS

The group of infrequent computer and Internet users is problematic for democracy [25]. Democracy requires certain amount of participation. People have to be active. The Internet is increasingly becoming the channel or medium for people to get information on the society and social services. It doesn't matter if the services are available virtually on the Internet or if they are real customer-official services in the social office. The customers are either well-educated or people with high standard of living, as the students in the Case Tritonia Academic Library. [26] For young people, the Net means additional value. They are able to look after things regardless of time and place. Young people use social services quite rarely, mostly when applying for study grants. The elderly, the immigrants and the sick as well as the unemployed are more likely to be regular customers of the social services – they often depend on social security. But they don't always know how to use computers and the Internet. It is also possible that they don't even have an Internet connection at home. [27]

The non-users are an interesting group of people. A typical non-user in Finland is a person over 75 years. People who use a computer and the Internet usually do it regularly. Nurmela et al. states [28] that even though an increasing number of the old have now begun to use information and communication technologies, there are nevertheless some indications of increasing polarisation. Those who have used new technologies are going to do it in the future, too. And on the other hand an increasing group of older people stay outside the use of ICT (Information and Communication Technology). The average age is rising all the time in Western countries. Because of functioning democracy it is important to make also the senior citizens take part in the social and political activities. It is important to arrange courses in information technology among people aged 50-75 and so overcome digital divide.

VI CONCLUSIONS

It seems that digital divide is no longer the consequence of economic factors in Finland and Sweden but more of lacking skills in using IT. Because of well working democracy, in a Habermasian sense, that gap in the use of ICT has to be overcome. In the Nordic countries there have always been great campaigns for popular enlightenment in public health, for instance. When trying to level out the digital divide education and enlightenment are the most effective means, not the economical aid or support. The

mmeybodi@aut.ac.ir

campaigns for information literacy have to be directed to the groups of older people, too. Otherwise the senior citizens will to stay outside the information society, they will be marginalized.

As seen in the two studies concerning 1) education of information literacy and 2) opinions about digital divide, the following conclusion can be drawn. It is rather simple to improve the skills in different kinds of sectors of information literacy. The young generation, students in IT and electrical engineering think that digital divide is a result of lacking skills in the use of ICT. Education is naturally only one but supposedly the best solution in leveling out digital divide. User-friendliness is almost as important as education.

It has been proved here that the concept of digital divide has got a new meaning in the Nordic countries. The stress is no more in factors like age, costs, family structure, income, geography, rural and regional factors, religion and so on, but the main cause of digital divide is the lacking skills in using the ICT.

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mmeybodi@aut.ac.ir

Brain Wave Games and E-Learning

Paras Kaul
George Mason University
4400 University Drive, MSN 2F7
Fairfax, Virginia 22030 USA
www.brainwavechick.com
jkaul@gmu.edu

***ABSTRACT*-This paper describes the development of brain games for e-learning using IBVA4, the fourth version of the Interactive Brain Wave Visual Analyzer (IBVA), an EEG biofeedback system. Unique to this brain wave interface is the complexity of interactivity established between neural signaling and multimedia, which interaction can occur through a Web browser via Internet. This technology enables game design with audio mixing and digital animation by brain wave. Brain wave games exercise and stimulate neural activity, thus accelerating perceptual awareness. Continuous brain wave gaming potentially awakens human awareness, thus enlivening the ability to monitor and control health. Brain wave gaming via Internet creates a brain wave community for users with the IBVA4 hardware and software configured on Apple Intel computers with high-speed Internet connections.**

Keywords
Brainwaves, biofeedback, IBVA, nonverbal communication, coherence, neurological, healing

I. INTRODUCTION

The intent of the paper is to present a method for extending educational methods through the use of brain games designed for e-learning and to present a way of thinking about creativity as an intuitive process related to health and brain wave coherence. In doing so, learning becomes an experiential activity via Internet that awakens the ability to visualize and perceive what previously has not been visible or audible. The paper analyzes and compares brain wave controlled gaming to what Eastern philosophies explain as a mental process whereby visualizations create the physical universe [1]. Eastern concepts are not based on scientific method and require individuals influenced by the Western culture to step out of the existing scientific paradigm in order to be receptive to new ways of thinking and researching enabled by interactive new media technologies.

Many cultures share the idea that health is related to a kind of energy or vital force that flows through the body [2].

When humankind understands the sophisticated design of human beings and acknowledges the bio-energetic aspect of being human, there will be greater awareness of the full potential of the brain. Using the brain's potential more completely creates a healthier human being with enhanced abilities for creative thought. Research at Princeton's Engineering Anomalies Lab suggests that there is evidence that consciousness plays a role in creating a physical reality [3].

As explained by Willis Harmon and Howard Rheingold, based on research at the Stanford Research Institute, the ability to know what is happening at a place one has never visited is not a rare talent, but a trainable skill, that is latent within all of us [4]. Acknowledging that abilities of this kind are real is helpful for understanding the significance of using brain games for neurological training.

Physicist Robert Jahn and clinical psychologist Brenda Dunne, through experimentation over a 25-year period at Princeton's Engineering Anomalies Research Laboratory describe their findings as related to anomalous information gathering in order to provide evidence that the mind can psychically interact with physical reality. Their findings support the idea that analytical and cognitive processes hinder anomalous experience and suggest that there is evidence of a relationship that exists between consciousness and the establishment of physical reality [5]. As the public begins to recognize their research, greater attention will be called to human potentials that have not yet been recognized. Managing the condition of the body and mind is the ultimate creative act.

II. INTERACTIVE BRAIN WAVE VISUAL ANALYZER (IBVA)

IBVA4 is a unique hardware and software interface, for Apple Inc.'s Intel computer systems. This brain wave system analyzes the coherence of neural signaling between the left and right hemispheres of the brain, in addition to monitoring the frequencies and amplitudes of neural

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 410–415.
© Springer Science+Business Media B.V. 2008

mmeybodi@aut.ac.ir

signaling. As stated in a previous publication, since the corpus callosum houses neural connections between the brain's left and right hemispheres, it is possible that coherence data from the brain are measurements of signals passing through the corpus callosum, which acts as a control center monitoring balance between left and right hemisphere neural activity, thus playing a significant role in perceptual awareness and creativity [6].

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Fig. 1. IBVA4 is packaged in a convenient case that contains software, Bluetooth receiver, headband for electrodes,and cable to connect to Apple Intel computers.

Earlier versions of IBVA have been used for research conducted by Dunne and Jahn in the Engineering Anomalies Research Laboratory. Using the fourth version of IBVA with the technical direction of Masahiro Kahata, programmer and developer of IBVA4, this author has developed several prototypes for brain wave games that have been presented at conference venues, such as the Special Interest Group for Computer Graphics and Interactive Techniques (SIGGRAPH) in the United States and the Dana Centre Museum of Science in the UK. Built into IBVA4's software is the ability to animate digital graphics with brain waves. This type of neural control demonstrates that brainpower has the potential to affect the physical reality. A step beyond brain wave controlled graphics is the psychokinetic animation of objects in real time.

III. BRAIN WAVE COHERENCE

The sophistication of interactivity between neural signaling and multimedia in the IBVA4 software allows a user to assign neural data to functions, which are assigned to visual and audio objects. Research related to coherence in neural signaling is less complete than the research related to left and right hemisphere frequency signaling. Similarly, research related to telepathy, intuitive processing, and precognition is also less prevalent than research related to cognitive data processing. In his book, *The Holographic Universe*, Michael Talbot explains that the reason for the disinterest in intuitive behavior on the part of science is that the current worldview has no explanation for paranormal events and that it is difficult to measure extrasensory abilities using scientific methods [7].

Using IBVA4, the technology is available to monitor and analyze data associated with intuitive processes. In doing so, it may be necessary to broaden the current worldview by introducing neurological education into school systems. Neurological learning increases brainpower, which heightens one's understanding of latent human capabilities. Regular practice with a brain game further develops these abilities that have become dormant for lack of use. Contemporary humankind has not called upon these skills because educational systems have not incorporated knowledge of how to use abilities as nonverbal communication, remote viewing, and self-healing into the educational process. Brain games available via Web browsers provide easy access to this new type of learning.

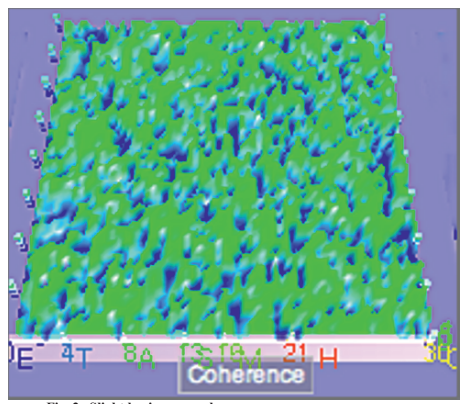


Fig. 2. Slight brain wave coherence

Viewing windows in the IBVA4 software show the visual representation of coherence signaling, which can be likened to viewing Swiss cheese in motion. The more holes that appear in the Swiss cheese, the less coherent the brain wave signals are. "Fig. 2," gives a visual representation of brain wave data that is not significantly coherent.

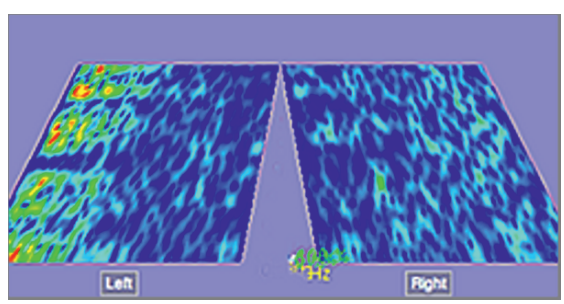


Fig. 3. Frequency and amplitude data that occurred in the left and right hemisphere the same time as the coherence data in Fig. 2.

mmeybodi@aut.ac.ir

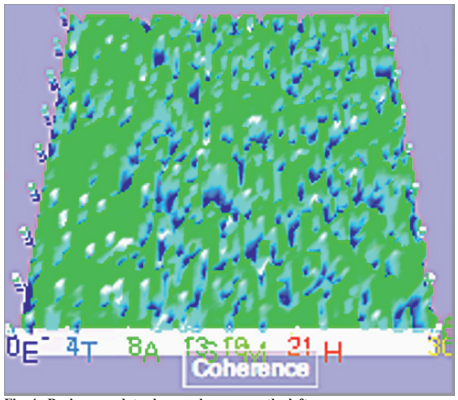


Fig. 4. Brain wave data shows coherence on the left of the image indicating coherent alpha, theta, and delta brain wave activity.

Fewer holes in the cheese with more solid patches represent more coherent signaling between the left and right hemispheres. "Fig. 4," shows greater coherence in the alpha, theta, and delta ranges. Analysis of the frequencies and amplitudes of neural signaling in each hemisphere is also significant as relates to human performance. Sustained low frequencies and low amplitudes of brain wave signals are conducive to focused attention and clarity of thought, as well as feelings of well being and good health. Disciplines as yoga and tai chi, which relax the body and regulate breathing facilitate this type of neural signaling.

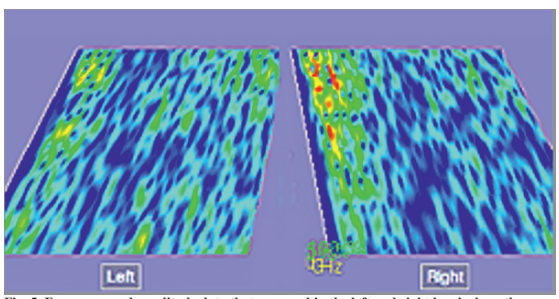


Fig. 5. Frequency and amplitude data that occurred in the left and right hemisphere the same time as the coherence data in Fig 4.

Mel Robin who acquired a Ph.D. in clinical physics in 1960 and devoted his career to research with molecular spectroscopy retired into a yogic lifestyle, whereby his research became an attempt to understand and explain how yoga and medicine are related. Results of Robin's research are consistent with results achieved by this author's brain wave analysis using IBVA to monitor brain waves of hundreds of individuals at conference venues at the Los Angeles and Orlando convention centers, as well as individuals having long-term experience with yoga, meditation, and tai chi. Analysis of data acquired from individuals trained in the Eastern disciplines indicates more coherence in brain wave activity and greater control of brain wave states. Robin states that as yoga students become more focused in meditative states, there is a shift of the predominant EEG brain wave patterns from beta alertness to alpha inner awareness and then to theta and delta inward quietude and harmony [8].

IV. Brain Wave Coherence and Perceptual Awareness

Similar to how the coherent flow of photons in a laser beam is able to wield the force of a surgeon's knife, greater coherence between the left and right hemispheres of the brain opens doors of perception enabling one's perceptual awareness to expand and tune into human abilities actualized by the coherent neural signaling. This author theorizes that there is a direct relationship between brain wave coherence and health.

The degree of coherence is related to the degree that brain wave frequencies in both the left and right hemispheres are equally sustained in one of the frequency domains: beta, alpha, theta, delta, or gamma. The longer the predominant signaling occurs in one of these domains, in both left and right hemispheres simultaneously, the greater the brain wave coherence. Coherent brain waves indicate balance between the two hemispheres, which balance occurs in conjunction with balanced body chemistries. Robin explains that when alpha brain waves are predominant, the heart rate, blood pressure, and respiration decrease. Respiration becomes even and gastrointestinal activity increases [9].

V. Brain Wave Gaming

Brain games for e-learning can be designed to help users develop greater coherence in brain wave signaling by learning how to control visuals and audio via brain waves. The gaming environments are designed with Apple Inc.'s Quartz Composer application and saved as movies which are uploaded to a server where they can be accessed from a Web browser. Continued practice in a gaming environment increases one's ability to animate visuals and audio. A brain wave gamer will produce greater results with coherent brain waves. The increased relaxation and focused attention that accompany greater coherence enhance the ability to brain wave switch. In this case, the visual representation of brain waves will appear as Swiss cheese with fewer holes.

In conjunction with brain wave coherence, animation in the gaming environment becomes smoother, and the gamer is better able to predetermine the movement of specific objects within the gaming environment. Audio volume and filtering are set from high to low using presets assigned to brain wave switches, which are used to control individual sound tracks. As brain wave control and coherence increase, sound becomes less chaotic, and musical

mmeybodi@aut.ac.ir

compositions sustain consistent volume and filtering. It is not easy to produce significant coherence in brain wave activity, and the degree of coherence required to enable latent abilities has not been substantiated by science and varies from one individual to another based on individual experience. High performance for gamers in a brain wave game is achieved with strong brainpower.

Using IBVA4, one easily witnesses ongoing changes in neural activity. This activity is constantly changing, and significant studies have been made to identify factors that influence changes in the neural data. Monitoring coherence, frequency, and amplitude data, and receiving biofeedback through the interaction with multimedia enable one to begin to identify factors contributing to changes in neural signaling. When gamers begin to associate factors that influence the signaling, they begin to develop the ability to willfully control the switching activity from one brain wave state to another. Robin's research also suggests that the EEG wave pattern can be changed at will [10]. Based upon years of research with IBVA, the author of this paper has experienced that the strongest brainpower occurs when the body and mind are functioning in a stress free mode. As stress is eliminated from the body and mind, breathing becomes more controlled, and short quick breaths cease.

As breath control increases, deep breathing begins to occur which better oxygenates the body. The oxygen replenishes the blood and nurtures body chemistries, which affects activity within the neural networks of the brain. With greater balance of body chemistries, mental clarity increases, and attention becomes more focused. The body and mind are better prepared for creative thought and for problem solving. Simple evidence of this is the fact that in the early morning, after a restful night's sleep, it is easier to perform and to solve problems. The more balanced the body becomes, the more coherent the brain wave activity becomes. As brain wave coherence increases, perceptual awareness also increases. Michael Talbot discusses Karl Pribram's views that perceptual awareness of the subtle vibratory aspects of reality become more dominant with increased coherence in brain wave signaling [11].

VI. NEUROLOGICAL LEARNING

Coherence in brain wave activity is not easy to achieve for individuals raised in the Western world, which is why it is important to introduce neurological learning into educational systems. The fast paced Western culture does not nurture coherent brain wave activity, especially since technology has become a major focus of the culture. Douchan Gersi, who has traveled the world studying extrasensory practices of indigenous cultures, which he describes as people of tradition, finds that paranormal behavior is more prevalent in these cultures and concludes that technology may actually be hindering human development.

In some ways Gersi suggests that using the rational and logical functions of the brain has turned off, at least temporarily, other brain systems, which provide us with the ability to communicate more emotionally and psychically and to do things that seem humanly impossible. He suggests that perhaps technology and rationalism are preventing us from expanding toward other realities, though he acknowledges that even in the Western culture, there are humans who somehow have been able to see beyond rationalism to activate latent capabilities that are not practiced in general. Gersi also suggests that we may be in a state of development now that will change as we evolve more completely [12].

With the increased focus on technological development, terms like intuition, psychic, and precognitive have been considered to be invalid for the growth of the mechanical universe. The future may require what in the past would be considered super human performance. Brain games enliven creative thought, which inspires achievement of the impossible. Among other things, these games are effective for learning because they are fun! They are experiential and train the brain while a user is at play. An additional advantage of brain wave games described in this paper is that you can design your own gaming environment using the Quartz Composer application in the developer's kit that comes with the OS X operating system. There is no need to purchase additional animation software.

VII. QUARTZ COMPOSER AND BRAIN WAVE SWITCHES

The Quartz Composer is a visual, object oriented graphic and animation application that allows users to create function and object patches. Function patches are assigned to object patches, and are controlled by brain wave switches designed with the IBVA4 software. Brain wave coherence, frequency, and amplitude data are assigned to the brain wave switches via the function patches.

mmeybodi@aut.ac.ir

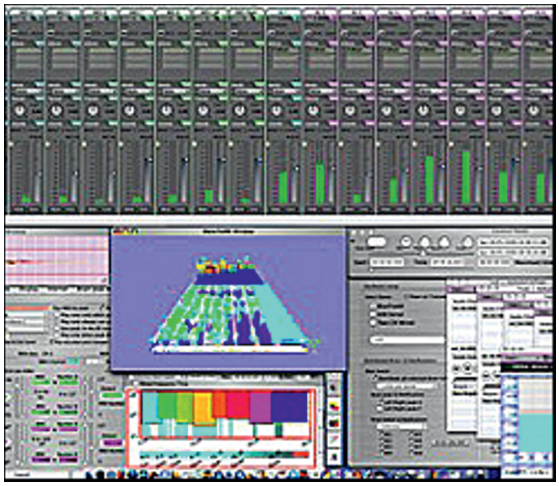


Fig. 6. Brain wave switches are defined in the boxes in the lower middle of the image. The Audio Unit's mixing board at the top of the image is controlled by the brain waves shown in the middle of the image. The switches appear as colored boxes.

These switches are box like structures that isolate areas of brain waves and encapsulate the parameter values defined by the boxes. Brain wave switches are used to assign neural controls for digital graphics as well as for individual audio tracks. Each isolated range of data assigned to a brain wave switch controls the animation of a designated object on the x, y, or z plane. Brain wave switches are able to control audio gain and filtering in sound tracks that are created in music applications that have the Audio Unit plug-in incorporated in their software.

VIII. WEB GAMING ENVIRONMENTS

Using IBVA4 in conjunction with applications that are provided with Apple Inc.'s OS X operating system, such as the Quartz Composer and GarageBand, three dimensional gaming environments can be developed that facilitate neurological healing. Gaming environments saved as movies in the Quartz Composer application and uploaded to a server are brain wave interactive to users wearing an IBVA headband with three electrodes. Brain wave signals input through a Bluetooth peripheral in the IBVA4 system interact with the Quartz Composer movie that appears in the browser Neurological gaming combines multimedia with neuroscience and accelerates learning by increasing brainpower.

Masahiro Kahata is the developer and programmer of IBVA4, which was first available in 1991. Currently the Bluetooth receiver peripheral is manufactured in Japan. Since 1997, Paras Kaul has used different versions of IBVA to produce prototypes for brain wave games. The first of these games was introduced at the Electric Garden Exhibition at a SIGGRAPH Conference in Los Angeles in 1997. Course content can also be incorporated into brain wave games, whereby the goal is to willfully influence changes in the gaming environment, while exercising the brain's ability to brain wave switch. The potential exists to create a variety of brain wave games in a variety of subject areas.xxxxxxxxxxxxxxxxxxxxxxxxx

IX. HOW TO PLAY BRAIN WAVE GAMES

In a traditional sense, many of the computer games on the market are designed to challenge a user's eye-hand coordination, which is not the primary challenge of a brain game. Brain games challenge one's ability to be still in order to allow the brain to function with balance in a coherent manner. In daily life, there are many types of stress that agitate our brain waves, which decrease the brain's function. Stillness clears the mental activity and influences the brain wave signals. Playing a brain game requires passive activity as opposed to aggressive behavior. A gamer becomes successful in a seemingly effortless manner and becomes relaxed and stress free while playing.

Brain wave states are defined by standard encephalographic (EEG) analysis of the signals that delineate brain wave states based on the frequency and amplitude of the signals. Brain games for e-learning and healing are more closely related to Eastern methodologies of mindfulness training, which are based on one's ability to quiet the mind. Quieting the mind eliminates noise factors in the mental space. Eliminating mental chatter enables focused attention, which increases awareness as to which brain wave state is predominant during a specific duration of time. The EEG feature of the IBVA4 software allows one to see and monitor visual representations of the beta, alpha, theta, delta, and gamma frequencies of brain waves, as well as the coherence of the signaling.

The act of playing involves the monitoring of one's brain waves using basic EEG analysis and practicing the ability to move the brain waves in and out of frequency and coherence states at will, also described as controlled brain wave switching. Prior knowledge of how to interpret visual data produced by EEG analysis is helpful; however, regular monitoring using IBVA4's viewing windows teaches gamers to interpret the data as an experiential process. With practice, one learns to sustain neural activity in a designated brain wave state for predetermined periods of time in order to strengthen brainpower, which increases mental focus and perceptual awareness.

X. CONCLUSION

If one visualizes a pendulum swinging from rationalism to the opposite end of consciousness, neurological learning needs to bring us from the extreme end of rationalism back to a balance between logic and intuition. There is a degree of brain wave coherence to be achieved that will allow us to harmonize with predominant frequencies of the cosmos.

mmeybodi@aut.ac.ir

When this balance is reached, humans will be in sync with what in the past has been described as the harmony of the spheres. Perhaps this is the balance needed to bring peace to our planet**.**

Actualizing extrasensory capabilities may be the next step needed to further communications with communities that depend on nonverbal communication. Rupert Sheldrake explains that such abilities involve what he explains as nested hierarchies of morphic fields, which are strongly stabilized by morphic resonance from countless people in the past. For this reason he feels that we are able to learn from people who are unknown to us who have previously acquired these skills [13]. Both David Bohm and Karl Pribram suggest that our brains mathematically construct objective reality by interpreting frequencies that are ultimately projections from another dimension, a deeper order of existence that is beyond both space and time [14].

Pribram's view, as described by Talbot is that reality is a frequency domain, and our brain is similar to a lens that converts these frequencies into the objective world of appearances [15]. Gersi discusses his conclusions in suggesting that there is a link between ourselves and the universe we don't know about yet [16]. Michio Kaku suggests that during the 20th century it may be understood that answers to the secrets of nature and creation may be found in hyperspace [17].

In his *Book Entangled Minds*, Dean Radin presents scientific evidence to support that psychic phenomena is real. He suggests that successful experiments have tested that information can be perceived without the use of ordinary senses and that other tests have been conducted that monitor the effects of mental influence at a distance [18]. Though the exact nature of the future may be unclear to us at this time, acknowledgment of the brain's full potential is necessary in order to prepare ourselves with the skills to become an interplanetary nation.

ACKNOWLEDGMENT

The author of this paper has published additional articles on the subject of brain wave games. The emphasis of each paper is different and is included as the author's ongoing research utilizing the IBVA brain wave analyzer for the purpose of furthering neurological education. The author also wishes to recognize and acknowledge the technical direction of Masahiro Kahata, programmer and developer of the fourth version of IBVA.

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mmeybodi@aut.ac.ir

Learning Property Management-Self-Regulation in Distance Learning

Patrik Skogster
Rovaniemi University of Applied Sciences
School of Technology
Jokiväylä 11
FI-96300 Rovaniemi
FINLAND
tel. +358-40-767 3780
fax +358-20-798 5495
patrik.skogster@ramk.fi

Abstract-**This study concentrates on self-regulation within distance learning. It is based on qualitative approach. The point of view is on higher education in Finland. As a result was found that self-regulation is a complex issue in all learning processes but especially in distance learning. Supervision has a strong influence on self-regulation within distance learning. However, some kind of social contacts are needed with other students.**

I. Introduction

Distance education is increasing exponentially [1]. This creates a need to examine students' personal study strategies when attending distance learning courses. Also the phenomenon of possible impact their study strategies have on their achievement appears. Moore and Kearsley [2] describe the relationship between level of learner self-management and degree of course structure as transactional distance, i.e., more independent learners succeed in distance courses with less course structure and interactive dialogue than less independent learners. Romano et al. [3] mention that a total web-based course has more transactional distance and requires more learner self-management than e.g. a blended course that is partially distance and partially face-to-face with instructors. This is especially true when comparing to pure face-to-face courses [4,5,6,7,8].

In a distance course, students tend to have more control over whether, when, and how they will study, and this increased freedom or opportunity for self-management may lead to a variety of study habits. [9] The need for self-regulation enhances [10].

The purposes of this study is to
(1) compare students' observed levels of their working habits for the same course and to
(2) examine the students' achievement and attitudes related to their observed study patterns

This study is based on a structuralist view of learning. According to structuralist theories [11], learning is an outcome of the learner's own activity. Learning is an active process in which earlier knowledge acquisition and experience guides learners to select and interpret the new information and to incorporate it within their existing cognitive knowledge structures. Conceptions of learning are based on the idea that learning is not only a process of knowledge but also a social interaction [11]. Learning is also considered to be a self-regulated process. Learners can improve their ability to learn through selective use of various strategies. Learners can potentially monitor, control and regulate certain aspects their own cognition, motivation and behaviour as well as some features of their environments [12]. Learners adapt or modify their strategy-use to fit situational demands [13]. Effective learning is often goal-orientated: to achieve their goals learners can choose the appropriate means and strategies or they can proactively select, structure and create advantageous learning environments [13]. From the self-regulations point of view learning is a situational phenomenon depending on the learning environment and social interaction [14,15,16,17,18].

II. Property management as a discipline

Comprehension of the multifaceted, multidimensional, substantial segment of the economy known as property management is best accomplished through a strategic framework [19]. Because the property discipline often lacks

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coherence and concurrence about what is the essence of property and what are the operative paradigms for comprehending and making order of the discipline, there is need for a pedagogic framework that is simultaneously synthesizing, integrating and comprehensive. The concept of the pedagogic property framework provide the basis for gaining insights into the property discipline and also presents a means to connect a strategic approach to property.

The pedagogic aim in this research was to give a student the basic knowledge about property management. By understanding the property management process, those strategic influences on transactions that follow from the real estate process can be identified. This framework can enhance the quality, reliability and prudence of property management decisions. By understanding these interdependencies and linkages, more effective decision making concerning property management interests and the objectives of participants in the real estate markets should be achieved.

III. Self-regulation as a theory

The theory of self-regulation is based on Bandura's [20] social cognitive theory. Students have goals and during their learning activities they observe, judge and react to their perceptions of goal processes. According to Zimmerman [21], self-regulation is the self-directive. Bandura established certain steps involved in the modelling process [5,20]

1. Attention. If a student is going to learn anything, he/she has to pay attention.
2. Retention. A student must be able to retain.
3. Reproduction. A student has to translate the images or descriptions into actual behaviour.
4. Motivation. A student is not going to do anything unless he/she motivated to learn.

Kelly [22] discussed about the motives of adult learners. Also Bandura [20] mentions a number of motives:

a. past reinforcement, traditional behaviorism
b. promised reinforcements (incentives) that can be imagined
c. vicarious reinforcement -- seeing and recalling the model being reinforced.

These themes are, traditionally, considered to be the things that "cause" learning. Bandura is saying that they don't so much cause learning as cause us to demonstrate what have been learned. That is, he sees them as motives. Also the negative motivations are there as well, giving a student reasons not to imitate someone:

d. past punishment.
e. promised punishment (threats).
d. vicarious punishment.

As a bridge to distance learning, Bandura's theoretical point of view about self-regulation is transferred to distance learning in this research through three aspects (Figure 1):

1. Self-observation. Students look at themselves and their behaviour keeping tabs on it.
2. Judgment. Students compare what they see with a standard. They can compete with others or with themselves.
3. Self-response. Students give rewarding self-responses if he/she performed well in comparison with personal standard. If he/she performed poorly, they give themselves "punishing" self-responses. These self-responses can range from the obvious and concrete (treating themselves to chocolate or working late) to the more covert (feelings of pride or shame).

Self-efficacy has been demonstrated to be an important aspect of performance in classroom-based learning [23]. The significant correlation between self-efficacy and final grades in this study supported findings [24,24,26] that there is a significant and positive relationship, either direct or indirect, between self-efficacy and performance in online education.

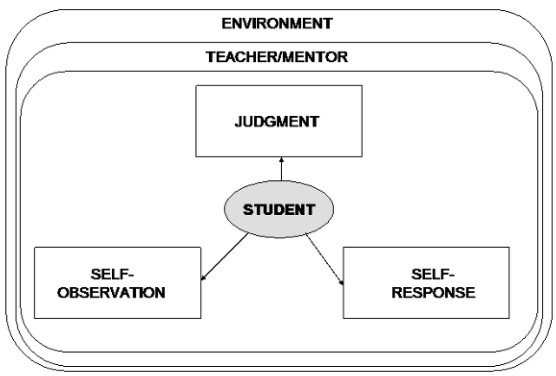


Fig. 1 Self-regulation framework in this study.
Adapted from Bandura (1986;1997)

IV. Methods

This study is based on qualitative approach. The point of view is on higher property management education in Finland. The analysis method is content analysis, because it was supposed to be suitable for interpreting the heterogenic empirical data. As Weber [27] mentions, in content analysis it is essential to categorise the data into simple classes. The aim is to reveal the relationships between the studied phenomenons clearly and to describe these phenomenons shortly and on a general level. The data is usually oral or written material produced by the participants [28]. In this research the empirical data consists of study diaries kept by students attending the courses given by the author. Data was collected from the students in two Finnish polytechnics and one Finnish

mmeybodi@aut.ac.ir

academic business school. The discussed issues were virtually similar within every course. The themes were real estate economics and management. The courses were mainly distance education with two-three key-note lectures.

According to Krippendorff [29], six questions must be addressed in every content analysis:

Which data are analyzed?
How are they defined?
What is the population from which they are drawn?
What is the context relative to which the data are analyzed?
What are the boundaries of the analysis?
What is the target of the inferences?

The data was collected during two scholar years (2004-2006), meaning that data was collected from six separate courses (see Table 1).

TABLE I.
AMOUNT OF STUDENTS ATTENDING THIS STUDY

Educational unit	*Year 1*	*Year 2*	*Total*
Polytechnic 1	6	8	14
Polytechnic 2	12	10	22
Business school	4	5	9
Total	22	23	45

As Weber [27] mentions, there is not one certain way for performing content analysis. The researcher must choose an appropriate method for the aim of the study. In this research content analysis was made with both inductive and deductive approach. The QSR NVivo7 software was used as an assisting tool.

V. Results

The students were asked to fill in study diaries every day when they were working with the course. The diaries include a large amount of different data, but for the purpose of this study were the self-regulative parts taken as the empirical data.

The study diary data was classified and grouped. The following groups were established:

A. Supervision

Individual comments:

- Respect for me as an individual
- Prestige
- Awards for the work done and punishment for the undone
- Knowing my supervisor trusts my skills, ideas and responses
- Having a written description of the duties for which I am responsible
- Being commended by superior when I do a good job or a bad job
- Getting a performance rating, so I know where I stand
- Opportunity for self-development and improvement whenever I feel to
- Having an efficient and competent superior

B. Social contacts

Individual comments:

- Attend staff meetings
- Getting along well with others on the job
- Formal and informal university wide communication, co-operation between departments and other students/staff
- Having regular staff meetings to discuss policy issues
- Socialising with other employees during the workday

C. Freedom

Individual comments:

- Not having to work too hard
- Being able to solve problems and report them in my learning process
- Having a flexible work schedule, curriculas need to be enhanced
- Having consistency in my job
- Having a job with minimal amount of pressure and obligations
- Large amount of freedom on the job
- Feeling studying is important
- Working by myself
- Being able to participate in the decisions that affect me
- Knowing I will be held responsible for my own performance
- Freedom to make decisions without approval from supervisor

D. Technology

Individual comments:

- Good physical working conditions, including network capacity, hardware and software
- Up-to-date technology and resources
- Chance to turn out quality work
- Opportunity to do creative and challenging work wherever I want

mmeybodi@aut.ac.ir

VI. Analysis

As an evaluation approach, content analysis is considered to be quasi-evaluation because content analysis judgments need not be based on value statements. Instead, they can be based on knowledge. Such content analyses are not evaluations. On the other hand, when content analysis judgments are based on values, such studies are evaluations [27].

Self-efficacy perceptions should be assessed pre-course in order to identify learners potentially at risk of course dropout or low performance. Efficacy enhancing activities and feedback should then be designed into the course as a means of assisting these students to successfully complete the course.

The sample studied was likely one in which self-regulation was not problematic. Distance learning creates pressure to reposition accreditation as a source of information about quality. The type of information students, the public, and government wants from accreditation is shifting toward more explicit yes or no responses to whether accreditation assures quality. This is a move away from accreditation judgments that traditionally have functioned more as diagnoses to improve quality rather than as either-or statements.

As mentioned before, the theoretical standpoint in this study is structuralistic. However, the results can be presented in a constructivistic way (Figure 2), where the basis of all distance learning is the used technology. Technology gives possibilities for student's self-observation to develop further. The results of this process is freedom, but on the other hand in this research one important reason for studying are social contacts.

Students created and explained this hierarchy quite similarly whether they were working on-line or off-line. But according to this research, there are no studying or results unless there are supervision in the back ground, sort of a "big brother" looking after the learning process.

In this paper cumulative learning refers to the case where an agent explicitly accumulates a store of knowledge that is extracted from solving multiple tasks and is useful for solving new tasks. The key issue in cumulative learning is that of recognizing, and exploiting, similarities between tasks. That human language is efficacious in this process is suggested by studies of analogical thinking in problem solving.

In terms of the relationship found in this study between self-efficacy and performance, course designers, administrators, and instructors should be aware that learners with low self-efficacy perceptions will likely be less autonomous and will therefore have greater difficulty completing the course

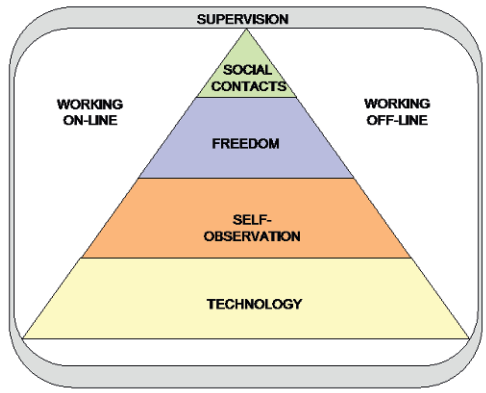


Fig. 2. Framework of cumulative self-regulation in distance learning

successfully than those learners with high self-efficacy perceptions. It is important, therefore, to identify such at-risk students prior to the beginning of a course in order to either direct them to a face-to-face course where less learner autonomy is required or to implement efficacy enhancing activities and feedback in the online course.

Learners with high self-efficacy are likely to employ adaptive self-regulatory learning strategies and study skills. Learner perceptions of personal efficacy, therefore, have a reciprocal relationship with the self-regulatory processes that affect motivation and performance. A high sense of self-regulatory efficacy enhances task performance efficacy, which in turn motivates further self-regulation in pursuit of further academic attainment.

VII. Implications and Further Research

The self-regulation theories and seem to work well with a distance education type of phenomenon. The learners apply similar results that e.g. Rovai [6,7] has found.

The motivational factors are in line with previous research [20,22]. Even the research with web as a tool seems to be logically repeated [3].

The most important contributions made by this study to the self-regulation process in distance education are that

1. Self-regulation is a complex issue in all learning processes but especially in distance learning.
2. Supervision has a strong influence on self-regulation within distance learning
3. Some kind of social contacts are needed with other students

mmeybodi@aut.ac.ir

This study has generated a number of possible opportunities for further research. E.g. course loads of independent students should be investigated. As well, there is a need to determine what changes in course design and student support services would be most beneficial. Similarly, further work is required to improve the research setting (e.g. interviews) and replicate the results. Sullivan [30] made a research about gender differences. This is a natural direction to move forward also with this research.

There are several suggestions for further research. First, research should be conducted employing a sample from a less homogeneous population than that employed in this study. Community college students studying online are likely to exhibit greater individual variability in terms of their self-regulatory skills. Secondly, although age and gender were not part of the research design for this study (they were included in the demographic section simply to provide a richer profile of the sample), such individual difference variables should be investigated in future research into the relationship between self-regulation and online learning generally. A third area meriting further research is investigation of the predictive value of those components of motivation (e.g., extrinsic motivation, value beliefs, control of learning beliefs, affective factors) and learning strategies (e.g., critical thinking, elaboration, meta-cognitive self-regulation, effort regulation) not included in this study. A fourth research area worth pursuing concerns identifying precisely which efficacy enhancing interventions are most effective in an online context.

Finally, there is also a need to investigate whether there are significant differences in the self-regulatory attributes that contribute to performance in different types of online education – e.g., blended versus purely online courses, more highly structured versus less highly structured courses, and the various blended course models now being designed and implemented in higher education. Research is required to investigate the unique characteristics of various blended learning models employing different blends of technologies, as well as different blends of face-to-face and online delivery of instruction, and how those varied characteristics affect learner performance.

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mmeybodi@aut.ac.ir

Training Geometry Teachers with Support of a Telepresence Tool

Pedro Esteban
Juliana Retrepo
Helmuth Trefftz

{pesteban, jrestre, htrefftz}@eafit.edu.co

Abstract

Teaching and learning of Geometry starts during the first school years, with the concepts of point, line, plane and with building figures, such as triangles, squares and others. Generally, the learning process takes place only inside the classroom and through Reading textbooks. This way of presenting the concepts does not take into account the forms and structures that are to be found in the students' environments, thereby wasting the opportunity to create links between the concepts and designs found in nature.

In this paper we present the result of a teacher training program in which a Telepresence tool was used as technological mediator and Teaching for Understanding (TFU) was used as pedagogical framework. The central theme of the course was "Spatial thinking and geometrical systems".

Keywords: Geometry, spacial thinking, teaching for understanding, telepresence, technological mediator.

1. Introduction

Science teachers training is an issue of the utmost importance. The growing deficit of good science teachers is a world-wide phenomenon. A proper use of technology can help in fostering the teachers' formation level in rural regions. It can also encourage more students to tackle scientific careers.

The widespread availability of the Internet in distance regions and the use of appropriate hardware and software, allow both students in instructors to gain access to large knowledge bases, which, in turn, allows them to broaden their knowledge and develop new ways to look at their environment.

The Telepresence tool described in this paper was developed at Eafit University by the virtual reality lab. The tool allows students and the instructor to be able to interact in one of the following manner:

- Share digitized voice in both ways. Students listen to the instructor's explanations and generate their own comments.
- The instructor can present video clips to illustrate the concepts at hand.
- Slides. The tool allows the instructor to use previously prepared slides.
- Interact with the illustrations of previously defined concepts. In the practical part, in which users interact with a simple collaborative virtual environment, the instructor can ask the students in order to measure whether they have understood the concepts and ask them to interact with the tool. Based on the interaction, the instructor can move to another concept or offer further feedback.

The Telepresence has been used in Mathematics, Physics and Computer Courses [1]. But this is the first time the tool has been used to train geometry teachers in a distance environment.

2. Using the Telepresence tool to train Geometry teachers

When designing the "Spatial Thinking and Geometrical Systems" for training geometry teachers, we tried to make extensive use of the Telepresence tool. Specific contents were created to illustrate various concepts of the subject.

In the first part of the course, the *point* concept was used as starting point in order to illustrate the axiom that states that "each point in a line corresponds to a real number". This concept is fundamental to the relationship between geometry, real numbers and algebra. Students that have not understood the mathematical (dimension-less) concept of point cannot formally understand mathematical analysis and other fundamental concepts of Calculus and other Mathematical knowledge.

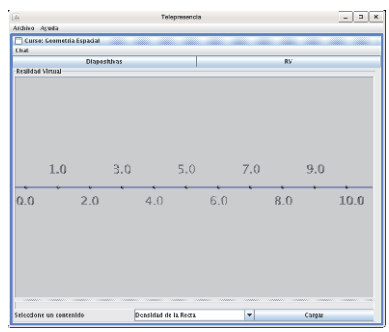


Figure 1. The association between real numbers and the line is illustrated. The uer can click on an interval and get more points and number whithin the interval.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 422–426.
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mmeybodi@aut.ac.ir

In a traditional classroom, visualization of geometrical concepts is associated with the instructor's drawings on the whiteboard and their own sketches on their notebooks. I.e., the idealization of the plane is fixed into the surface of two objects: the whiteboard and the paper sheet. Early on, students can be taught to observe the construction of geometrical figures in various planes and to look at the constructs of their drawings from various perspectives. Based on this idea, a content was developed allowing diverse planar figures to be drawn on an idealization of 3D space (see figure 2).

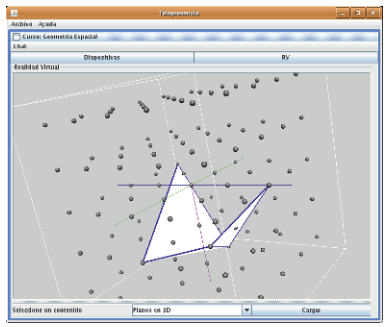


Figure2. Simulation of the 3D space in which various planar figures can be drawn.

In general, the geometrical concepts associated with the line (distance, axiom of the rule), the plane (construction of planar figures and their attributes) and space (volumetric attributes) in a separate manner, without any consideration to the most appropriate way for the student to realize the transition among the different dimensions. This issue has not been given enough attention in the schools. An example of this issue could be to consider how equation $y=sin(x)$ is displayed in space. It could be represented as $x=sin(x)$ or $z=sin(y)$. These ways to transit from 2D to 3D can be taught in elementary courses, allowing students to create an image of a dynamic (non-static) geometry.

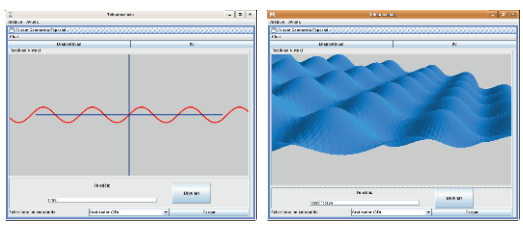


Figure 3. A 2D function and its transformation into 3D space.

All the contents allow both the instructor and students to manipulate the virtual objects, regardless of their physical location. All participants in the collaborative session can see the updates done by other participants.

The contents and the interaction were designed with the TFU pedagogical framework in mind.

3. The pedagogical model used in the experience

Teaching and learning of scientific concepts, during various historic periods, is influenced by the leading lines of thought of the period. Currently, one of the leading pedagogical frameworks that has gained wide acceptance in schools is Teaching for Understanding (TFU), which originated in the Harvard Graduate School of Education. An extensive research involving teachers and students of all education levels. Their objective was to "pin down the characteristics of true understanding – and the lack of it-" in order to find out the pedagogical actions that instructors can undertake in order to promote understanding. Based on the research, a new theoretical framework and model were created to represent the elements of understanding and the relationships among them. The idea is to design and organize the classroom experiences so they become meaningful for all participants" [Jaramillo1999].

Teaching for Understanding was created as result of the above mentioned research, answering questions such as: (i) What strategies should teachers implement in order to help students achieve profound understanding? (ii) How can the teacher know what have students really understood? How do students manifest their understanding of the course topics or unit? How can the instructor support the student to consistently achieve understanding? What tasks are more appropriate to develop understanding in the students? These and other questions are useful to determine the knowledge, skills and understanding that are fundamental to the education process [Stone1999].

TFU proposes four (4) dimensions of understanding: (1) Contents: directly related to the curriculum (2) methods: ways to create new knowledge (3) Praxis: how the knowledge is put into action and (4) Communication forms: related to the specific language of the area of knowledge [Blythe1999].

Teaching for understanding also proposes four components of understanding: (1) Goals of understanding: what level of understanding will students achieve? (2) Generative topics: What motivates students to learn the new concept? (3) Performances of understanding: What activities do student undertake in order to increase and demonstrate the understanding? (4) Continuing evaluation: How is understanding measured as the course advances? [Blythe1999].

The pedagogy of TFU allows the student to take advantage of his/her experience in order to integrate new technologies and resources for students to develop new abilities, skills and understanding that are not possible in a traditional classroom activity.

This pedagogy allows the instructor to determine (i) the topics that are really important in the development of the course, and (ii) topics that students can pursue by themselves without dedicating resources that should support the more important topic. It also encourages the instructor to propose new challenges to the student, allowing him/her to make use of his/her best developed intelligence, thereby discovering his/her potentials. [Gardner2001].

mmeybodi@aut.ac.ir

TFU is a flexible pedagogy that instructors can use in the preparation of their courses, providing instructors and students to attain new and more profound levels of understanding from the course. When applying this pedagogy, the instructor can define short- medium- or long-term objectives, allowing for a scaling process of personal objectives.

TFU integrates diverse methodological approaches in order to foster students' understanding of the topics that are fundamental for the knowledge construction of the subject, starting from the students' interests and needs. This pedagogy does not have to be implemented in a unique way. How it is presented to the students and the instructor's own understanding play a fundamental role in proposing the knowledge.

TFU use used as pedagogical framework in the course "Spatial thinking and geometrical systems", taught as distance education with the support of the Telepresence tool. Students of this course were school teachers from El Peñol, a small town in Antioquia Colombia. The instructor of the course was at Eafit University.

4. Design of the Spatial Systems and Geometrical Systems course

Throughout the process, the idea was to expose the teachers to how TFU was implemented in the course. In order to achieve this, teachers received a seminar on the TFU pedagogy, and they took part of the construction of the actual course, allowing them to integrate their pedagogical experiences. They were also asked, in turn, to use it with their own students.



Figure 1: A group of teachers discuss how to implement TF in the course "Spatial thinking and geometrical systems".

The course was designed as follows:

- Conducting thread. Is a constant that connects the various parts of the course. It should become an invitation for students to actively take part of building their own knowledge. For this course the conducting thread was: How does geometry help me interpret the world I live in?

This conducting thread shows clearly that the intention of the course is to allow participants to observe the world and reason about the geometrical forms that it contains.

  - **Generative Topics.** Generative topics are related to the aspect that needs to be emphasized in the course. The generative topic for the course was defined as: Which objects that I use on a daily basis have geometrical shapes?
  - How can I create new geometrical forms starting from others?
  - Design links between geometry and other subjects using geometric properties as starting point.

These topics aimed at centering the attention of the teachers (and their students) on their environment and find similarities of the physical objects with geometrical constructions.

- **Goals of understanding.** These are the learning objectives that have to be achieved at the end of the process. The instructor and the students should focalize on these goals. The following goals were designed for the course:
  - Students will understand the basic geometric concepts based on elements of their environment.
  - Students will recognize various geometric patterns and will use them to build their own.
  - Students will establish links between various geometrical forms and other subjects in the curriculum.
  - Students will describe and draw various applications of geometry to other situations in their lives.
  - Students will compare similar geometrical figures according to diverse measuring systems.

Understanding is a function of the students' ability to establish links between a concept and other aspects in their environment. This link has to lead, in a natural way, to the design and construction of physical objects, which should serve as measure to manifest the concepts at hand.

- **Performances of understanding.** These become the way how participants manifest their understanding of the concepts in the course. The idea is for them to express the knowledge in diverse manners: using language, alternative media (collages, physical constructions, etc…). The performances defined for the course were:
  - Students will create diverse designs starting from their own.
  - Students will describe the process of creating their own designs starting from models, drawings, short papers and oral expositions.
  - Students will propose modifications to their designs and will find new, different uses.

One of the fundamental parts of TFU is the fact that students should realize knowledge manifestations that their peers and other people can recognize as such.

- **Continuous Assessment.** This is a process integrating various aspects in the course. Instead of performing exams, the idea is to have a continuous evaluation process involving every activity developed by the group. The assessment was defined in this course as follows:
  - Students will explore their environment and various textbooks in order to observe and identify various applications of geometry. They will write an essay with the results.

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- Students will write down their observations in a field diary that will be presented to the instructor in a periodic manner for evaluation.
- The instructor will write down his/her comments and evaluation on the student's field diary.
- Students will report their advances to the whole group.
- Students will choose a physical structure in their environment and describe as geometrical object.

The way to implement continuing assessment has to be defined to the students from the beginning of the course. The results of the evaluation have to be posted in a place visible to all students.

- **Portfolio.** The portfolio is an instrument that allows students to document their advances in the understanding of the fundamental concepts of the course. This allows the instructor to follow the key aspects, student by student. During the course, the following parts were established:
  - Exploratory phase. Students will document their observations using drawings or collages of geometry-related objects. The instructor will create a synthesis of the most relevant aspects found by the students and described in their field diaries.
  - Guided research. Students will choose a structure of a physical object in order to study all the geometrical aspects thereof.
  - Final synthesis performance. Students will construct a mockup of the selected structure and create a document describing all the geometric concepts that comprise the mockup. At the end of the course, students will have a collective socialization of the results with other students and school administration.

The portfolio is an important instrument that allows the instructor to dimension and assess the understanding achieved by each student along the course.

5. Results

The design of the course using the guidelines of TFU was highly motivating for the teachers in the course. One of the most important aspects is that the teachers, as the course advanced, implemented TFU in their own courses in their classrooms. In this way, participants re-structured their courses and adapted it to their needs in the classroom.

The particular designs created by the teachers originated the following particular views of geometry:

- Algebraic geometry. A group of teachers integrated geometry with algebra, allowing students to create natural links from one to the other through the concepts of length, area and volume.
- Geometrical forms in crops. Crops follow highly geometrical patterns. Some teachers work in rural areas. Their interest and their students' were centered on various patterns used by the farmers in order to arrange their crops.
- Geometrical structures of crystals. A group of Chemistry teachers became interested in studying the geometrical structures found in ice and other crystals found in nature.
- Geometry and art. One teacher, and his students, studied how diverse geometrical forms used in various historical periods affect our perception of beauty in art.
- Geometrical forms found in natural "packaging". They studied how nature protects various natural products with natural packages that protect them.

In the design of these courses, the implementation and the achievements when TFU is applied hand in hand with the Telepresence tool.



Figure 3: Some objects modeded by the students and socialization of the final performances by the end of the course.

6. Conclusions

The integration of technology and pedagogy in the formation of geometry teachers allowed teachers to choose their own projects and develop them with their students. This is a fundamental issue, since the formation transcends the teacher's own interests when they take the newly acquired pedagogical practices to the classrooms, potentially developing a more profound mathematical thinking in the new generations. In the evaluation done by the participating teachers, the following aspects were mentioned:

Technological part:

O Formation of the teachers in the use of freely available resources from the Internet (applets, specialized pages).

O Integration of computer-mediated distance education tools (Telepresence, e-mail, mathematical software, learning management systems) for the development of the various modules of the course.

O Reflection on the importance of technology in the formation of the new generations of students.

O Utilization of the various resources available at each school in order to use them in the construction of geometrical concepts.

Pedagogical part:

O Formation of teachers in TFU.

O Design of didactical units, by the participating teachers, based in TFU. These skills were used, in turn, with their students in their courses.

mmeybodi@aut.ac.ir

O The design of didactic units using TFU had a motivating effect in students, encouraging them to establish links between their environments and geometry. Students undertook Works in which they showed deep levels of understanding of the concepts at hand.

O TFU taught teachers how to integrate their teaching experience in order to motivate students to understand the relationship between geometry and their environments.

In this experience, as in previous ones [1], [2], [3] the proper integration between pedagogy and technology have permitted both teachers and students to improve the understanding of the concepts and to better applies them.

7. Future Work

The group is proposing the local government to replicate the experience with teachers from other towns, also with support from the province government, whether on geometry or other subjects that can be taught using the tool, such as anatomy, physics, etc…

8. Acknowledgements

This experience was possible, in part with the support from the local government of the Antioquia Province and Eafit University (Project 28-0000001). We also thank the teachers from El Peñol for their participation and collaboration. We also thank Federico Builes and Juan Esteban Pemberthy, current developers of the Telepresence application.

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mmeybodi@aut.ac.ir

A Fuzzy Approach to Solving Multicriteria Investment Problems

Ivan Popchev[1], Penka Georgieva[2]

[1] Institute of Information Technologies
Bulgarian Academy of Science
Acad. G. Bonchev St., Block 2
1113 Sofia, Bulgaria

[2] Burgas Free University
Faculty of Engineering and Computer Science Studies
62, San Stefano Str.,
8000 Burgas, Bulgaria

Abstract- Financial mangers have to make decisions under many restrictions and often have to deal with vague and imprecise information. In multicriteria problems, the best solution is sought in a set X of alternatives under certain constraints with rates of contentment $\mu_i : X \to [0,1]$. Considering these rates as membership functions, the tools that fuzzy logic provides is adequate to solving a multicriteria investment problem. In this paper, a fuzzy approach for assessing the quality of an asset and making an investment decision based on this assessment is proposed.

I. Introduction

Assessing the characteristics of potential assets is a key issue in managing individual finance investments as well as in managing finance portfolio investments. Since an investor seeks maximal possible return combined with minimal possible risk, in the decision making process at least two criteria have to be taken into consideration. Return and risk are the most common measurements in different models. They are obtained either from historical data or by subjective probabilities [1], [2], [3], [6], [8]. The precise determination of these characteristics is the basis for a good initial investment and proper investment management in time. Investors' decisions are based on the degree of satisfaction of certain criteria often in conditions of vague and imprecise available economic information and are an optimal solution in a set X of alternatives [4]. This optimization problem could be solved with the tools of fuzzy logic if the degrees of satisfaction of the criteria are treated as membership functions of fuzzy variables $\mu_i : X \to [0,1]$.

In this paper, a fuzzy logic based model for assessing financial assets and taking an investment decision is proposed. The input variables are the key characteristics of an asset $K_1 = \{return\}$, $K_2 = \{Risk\}$ and an additional one $K_3 = \{r / R \ \ ratio\}$. The decision about asset valuation is an output variable $Q = \{quality\}$.

II. Model

Return

Let A be a financial asset and $P_1, P_2, ..., P_T$ is a sequence of historical data for the price of this asset in moment t, $t = 1, 2, ..., T$ (P_t is the market price of the asset at the end of each of T subsequent periods).

Then the return of the asset for the moment t is $r_t = \frac{P_t}{P_{t-1}}$, $t = 2, ..., T$.

The Annual Norm of Return (ANR) is calculated as $ANR = AR - 1$, where $AR = \sqrt[T-1]{\prod_{t=2}^{T} r_t} = \sqrt[T-1]{\frac{P_T}{P_1}}$ is the geometric mean of the returns.

Despite of the fact that the geometrical mean of returns AR is an accurate measurement for how the invested capital has changed the logarithms of returns and then arithmetic mean of log-returns is more suitable for examining the dynamic changes in return and risk:

$$\overline{r_g} = \ln(AR) = \ln\left(\sqrt[T-1]{\prod_{t=2}^{T} r_t}\right) = \frac{1}{T-1}\sum_{t=2}^{T} \ln r_t \quad (1)$$

The following equality holds:

$$AR = e^{\overline{r_g}}.$$

In the proposed model the quantity $r = ANR - r_0$ is used, where r_0 is an additional constraint and it could be the

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 427–431.
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mmeybodi@aut.ac.ir

required minimal rate of annual return, or the return of the risk-free asset, or any other threshold parameter.

Risk

The common measure of risk in investment theory is the variability of returns. Different statistical tools, based on probability distributions and most often the variance of the returns, are used to calculate the variability [2], [3], [7]. In the proposed model, the estimator of variance is the arithmetic mean of log-returns:

$$s^2 = \frac{1}{T-2}\sum_{t=2}^{T}\left(\ln(r_t) - \overline{r_g}\right) \qquad (2)$$

As a measure of the risk the quantity $\sigma = s - \sigma_0$ is used, where σ_0 is the upper limit of the risk that the investor can take.

Return-to-Risk ratio

In the proposed model, a new characteristic is introduced – Return-to-Risk ratio q. This ratio is calculated as

$$q = \frac{r}{\sigma} \qquad (3)$$

and shows to what extend the risk taken by the investor is justified. Every investor aims at maximum return and minimum risk, thus for the *Return-to-Risk* ratio q maximal values are sought. There are other measures of the proportion between mean and variance, but in this model, a degree of quality of the asset is introduced and so Return-to-Risk ratio is an appropriate characteristic. Indeed, if Return-to-Risk ratio is small (e.g. small return, great risk) the asset is not attractive to the investors and vice versa.

Model description

In the process of investment decision making, uncertainty in data is an important condition that cannot be ignored. Besides an investment manager faces several criteria - either constraints or restriction and has to consider a decision problem finding the best decision in the set of feasible alternatives with respect to several criteria functions that are within the range [0, 1] (or could be mapped to this interval) and therefore fuzzy approach is applicable [4].

In the proposed model, the criteria are high return, combined with low risk and good quality of the asset

The asset evaluation in the proposed fuzzy system is based on historical market prices. In the example, the prices of 12 arbitrary chosen assets listed on Bulgarian Stock Exchange are used. The period of the observations is from 10.09.2004 till 13.06.2007 and the data has been extracted by a real-time Perl based data acquisition system [10]. Return, risk and Return-to Risk ratio are calculated For each asset according to (1), (2) and (3). These values are fuzzified and thus they become input variables for the fuzzy system. Then the quality of the asset is derived by firing fuzzy rules in the FuzzyToolBox module in MatLab (fig. 1).

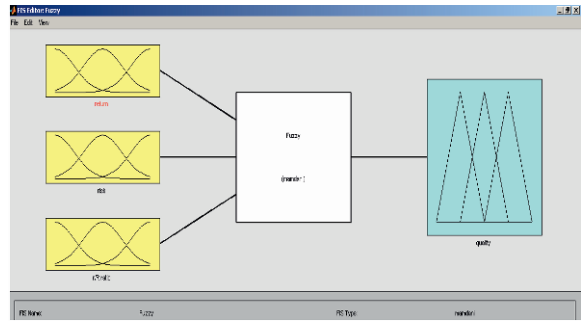


Figure 1. Fuzzy system for asset assessment

Fuzzy input variables description

The input fuzzy variable $K_1 = \{return\}$ consists of five terms: $very_low; low; neutral; high; very_high$ (fig.2).

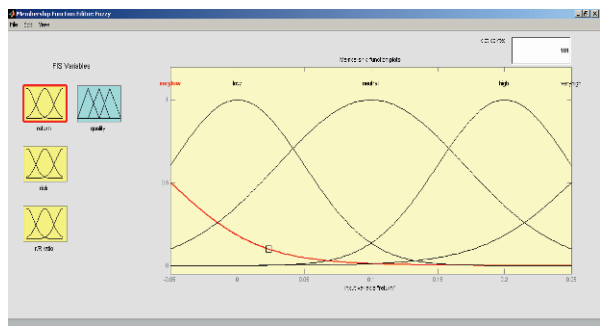


Figure 2. Fuzzy variable $K_1 = \{return\}$

The first and the last terms are sigmoid functions and all the others are Gaussian functions of type 1. The parameters of the term variables are shown in table I.

TABLE I

PARAMETERS OF TERM VARIABLES OF $K_1 = \{return\}$

Term	Type of membership function	Parameter 1	Parameter 2
very_low	sigmf	-30	-0.05
low	gaussmf	0.05	0
neutral	gaussmf	0.007	0.1
high	gaussmf	0.05	0.2
very_high	sigmf	30	0.25

mmeybodi@aut.ac.ir

The input fuzzy variable $K_2 = \{Risk\}$ also consists of five terms: $very_low; low; neutral; high; very_high$ (fig.3.), but with different parameters.

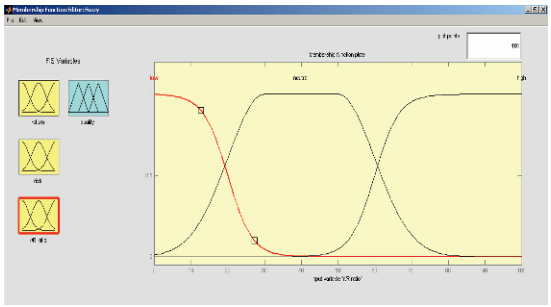


Figure 3. Fuzzy variable $K_2 = \{Risk\}$

The fuzzy variable $K_3 = \{r/R\ ratio\}$ consists of three terms: $low; neutral; high$ (fig. 4). The membership functions of the terms low and $high$ are of sigmoid type, while the term $none$ has Gaussian membership function of type 2.

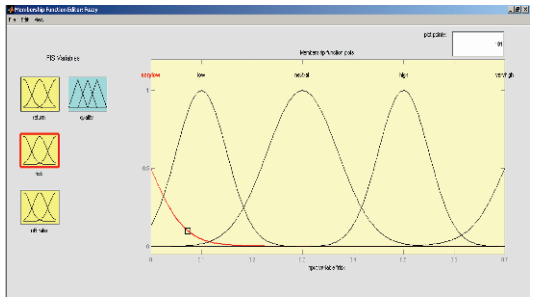


Figure 4. Fuzzy variable $K_3 = \{r/R\ ratio\}$

Fuzzy output variable description

The output variable $Q = \{quality\}$ has five terms: $bad; not_good; none; good; very_good$ (fig. 5) all with membership functions of Gaussian type 1 with the corresponding parameters.

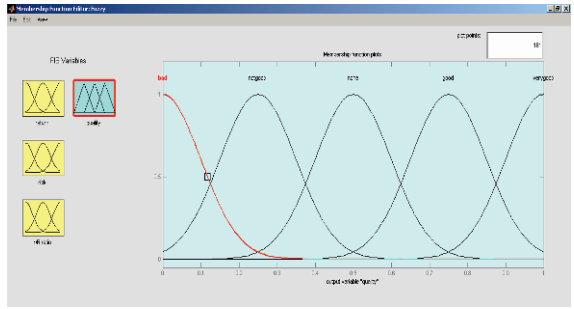


Figure 4. Fuzzy variable $Q = \{quality\}$

Rules for decision-making

For making the decision about the quality of the asset three criteria are taken into consideration – high return, low risk and high Return-to Risk ratio. The quality of an asset is assumed as *very good* if it has very high or high return, very low or low risk, and high Return-to Risk ratio that shows that the risk taken is justified by higher return. The Mamdani min operator is used for aggregation and defuzzification is done following the centroid method [9], [11]. In the model, 24 rules with corresponding weighs are applied and the first 10 of them are shown in table 3.

For instance, rule 1 is:

IF $(K_1$ is $very_high)$ and $(K_2$ is $very_low)$ and $(K_3$ is $very_low)$ THEN $(Q$ is $very_good)$

TABLE II

RULES FOR DECISION MAKING

№	$K_1 = \{return\}$	$K_2 = \{risk\}$	$K_3 = \{r/R\ ratio\}$	$Q = \{quality\}$	*Weight*
1	*very_high*	*very_low*	*high*	*very_good*	1
2	*very_high*	*low*	*high*	*very_good*	1
3	*high*	*very_low*	*high*	*very_good*	1
4	*high*	*low*	*high*	*very_good*	1
5	*very_high*	*very_low*	*high*	*good*	0,8
6	*very_high*	*neutral*	*high*	*good*	0,8
7	*high*	*low*	*high*	*good*	0,8
8	*high*	*neutral*	*high*	*good*	0,8
9	*very_high*	*very_low*	*neutral*	*good*	0,8
10	*very_high*	*low*	*neutral*	*good*	0,8

The result after firing the rules for a case with return=0.15, risk=0.20, r/R ratio=75 is shown on figure 6. The obtained value for the quality of the asset is 0.727.

mmeybodi@aut.ac.ir

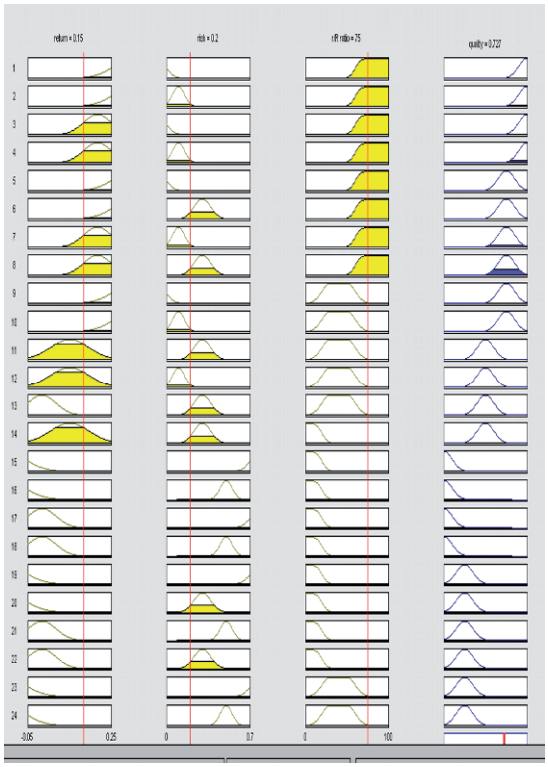


Figure 6. An example of firing the rules

III. Example

The results from the fuzzy system for taking an investment decision are tested by using real data from Bulgarian Stock Exchange for 12 assets: ADVANC; ALBHL; BHC; CENHL, CHIM, DOVUHL; GAMZA, LEV, PETHL, RAZHL, SOFBT and ZLP. The values of the input variables and the values of the output are shown in table III.

Table III

Characteristics and Quality of Assets: ADVANC; ALBHL; BHC; CENHL, CHIM, DOVUHL; GAMZA, LEV, PETHL, RAZHL, SOFBT, ZLP

	Return	***Risk***	***r/R ratio***	***Quality***
ADVANC	1.9400	0.3128	6.2020	**0.6506**
ALBHL	8.4600	0.9502	8.9034	**0.6198**
BHC	1.3218	1.5662	0.8440	**0.4908**
CENHL	4.2890	0.4155	10.320	**0.6106**
CHIM	0.9074	0.2634	3.4449	**0.6963**
DOVUHL	2.7644	1.6758	1.6496	**0.5000**
GAMZA	2.1211	0.9732	2.1795	**0.5192**
LEV	1.5456	0.3564	4.3367	**0.5334**
PETHL	5.6267	0.9735	5.7799	**0.6434**
RAZHL	6.3000	4.4242	1.4240	**0.5000**
SOFBT	0.9690	0.8156	1.1881	**0.5395**
ZLP	2.2506	1.1504	1.9564	**0.5146**

As can be seen from table III neither high return nor high Return-to-Risk ratio only guarantees good quality of the asset. For instance, RAZHL is not the best choice for investment no matter it shows excessive return. In the same time CHIM, though having the lowest return, shows best quality.

In financial world, it is important to know what happens with the amount of money invested in a particular asset. Assuming that an investor spends 100$ on each of the assets on 13.06.07, the change of this sum over time shows how good the investment is. In table IV the assets are sorted by their quality (column *Quality*100%)* and then the prices on 20.06.2007, 27.06.2007 and 04.07.2007 are used for calculating the change in each investment.

Table IV

Change in a 100$ Investment on Each of Assets: ADVANC; ALBHL; BHC; CENHL, CHIM, DOVUHL; GAMZA, LEV, PETHL, RAZHL, SOFBT, ZLP

	Quality* 100%	***20.6.2007***	***27.6.2007***	***04.7.2007***
CHIM	69,63	107,95	109,33	127,17
ADVANC	65,06	99,34	102,31	106,27
PETHL	64,34	98,89	103,23	119,02
ALBHL	61,98	99,58	103,47	108,78
CENHL	61,06	102	104,33	13,77
SOFBT	53,95	n.a.	n.a.	n.a.
LEV	53,34	97,29	97,93	96,65
GAMZA	51,92	99,35	99,67	100
ZLP	51,46	96,28	98,14	n.a.
DOVUHL	50	100,58	100,15	108,91
RAZHL	50	91,4	88,45	83,78
BHC	49,08	101,94	99,78	99,78

The leaders in *Quality* (CHIM, ADVANC, PETHL and ALBHL) shows steady increase in price over time while the assets with *Quality* less than 60 either show decrease in price or have unstable prices over time. The only exception is CENHL, which had a dramatic fall in price at the end of June 2007.

IV. Conclusion

There are different methods to approach and solve multi-criteria problems. In financial world, where the decisions have to be taken under many constraints with sometimes imprecise and vague information, acceptable results can be derived with fuzzy approach. In this paper a model based on fuzzy

mmeybodi@aut.ac.ir

reasoning is introduced. In the model, three criteria are used to support the investment decision-making process with a measure of the quality of a financial asset. The model is applied and tested to twelve arbitrary chosen assets from Bulgarian Stock Exchange. Results about the quality of these assets are obtained.

An investor can use the information about the quality of an asset in managing an individual asset – e.g. choosing the "best" asset.

The results from the proposed model can be used for asset allocation in investment portfolio management. In this point an investor can choose shares x_j of asset j to be equal to $x_j = \frac{Q_j}{\sum_{k=1}^{n} Q_k}$, where Q_j is the *Quality* of the $j-$th asset, $j = 1, \ldots, n$.

Though the achieved results are satisfactory, the model can be developed in different directions – decision making in real time, predicting future returns and risks, adding new criteria.

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mmeybodi@aut.ac.ir

Strengthening University-Industry Linkage in Developing Countries Through International Cooperation: Case of Sri Lanka Through Cooperation of Toyohashi University of Technology, Japan

H. Homma, N. Ikeda and R.A. Attalage
International Cooperation Center for Engineering Education Development (ICCEED)
Toyohashi University of Technology (TUT)
1-1 Tempaku-cho, Toyohashi, Aichi 441-8580, Japan

Abstract -The paper aims at highlighting the importance & the role of the University-Industry linkage in fostering the development of engineering education in developing countries. International cooperation is employed as the tool for strengthening this link and the pilot project on the faculty of engineering, University of Moratuwa, Sri Lanka (UoM) through the efforts of the International Cooperation Center for Engineering Education Development (ICCEED) of Toyohashi University of Technology (TUT), Japan is described. The project implementation strategy & current status are presented and the expected output is highlighted.

1. Introduction

1.1 Importance of University-Industry linkage in Engineering Education

In the strategy for promoting the knowledge intensive economic development, engineering education and research plays an utmost important role in order to enable the competitive use of knowledge for innovation and for providing solutions to the challenges of the humankind. It is the excellence in this science/engineering education and research that gives a country a competitive edge over the others with reference to the economic development.

The excellence in engineering education and research is attributed to many factors among which the university-industry linkage has proven to be very important. It is the most effective mechanism where both the university and the industry act as complementary organizations to share resources to achieve a common goal. The linkage would permit the flow of much needed funding to carry out research in universities either sponsored or collaborative nature, put into meaningful use of the knowledge & skills of the academics, possibilities of innovations of value to both university & industry respecting intellectual property rights, make use of the resulting industry experience back in the teaching programs & postgraduate research and national level contribution for local technology development. The strength of the university-industry linkage will depend on the closeness, mutual understanding of strengths & weaknesses, confidence with reference to either parties and on the effectiveness of the management of the activities in the linkage.

1.2 The Role of International Cooperation

Experience has shown that engineering education and research thrive on exchanges across borders of all spheres. In this context, International Cooperation is recognized as an important mechanism that is mutually beneficial to the parties by whom the cooperation is formed of. From the perspective of developing countries, it has proven to be a handy mechanism with reference to engineering education & research, as an effective means of human resource development & institutional capacity building in regionally competitive local technological development. Moreover, the stimulation & synergy resulting from international cooperation can enhance the quality of research undertaken and reduce the financial burden. On the other hand, from the perspective of developed countries, international cooperation has been able to attract talented students who are eager to learn & conduct research under well-developed infrastructure. This enables the developed countries to enhance their quality of education, sustain their research activities, which in most cases threatened by diminishing interests of local students and also to get to know the technological needs in developing countries more precisely thereby opening new avenues for innovation [1]. Finally, on a global perspective, it will enable both developed as well as developing countries to work on a common platform to meet global challenges of economic & social development in a sustainable manner. This is an important element to all developing nations.

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2 Challenges Faced By University-Industry Linkages In Developing Countries

2.1 University-Industry Linkage Strategies in Developed Countries

University-industry linkage became an important element in the higher education policy circle even in developed countries only in the latter part of the 20th century. This was considered as a means of keeping up leading edge research, transfer & application of knowledge for social development and international competitiveness and had resulted in a drastic increase of commercialization of public research [2]. University-industry linkage facilitating the complementary advantages of working towards a common goal has been the major driving force in earnings of both parties. Provision of venture capital, intellectual property regulations and a national innovation system are specific features related to university-industry linkage in developed countries. Having reached the state of a strong research & development base, the usual measures employed for the promotion of university-industry linkage are structural measures comprised of collaborative research centers, incubators, innovation & science creation centers, science & technology parks, etc.

2.2 Challenges Faced by Developing Countries in Employing Models of Developed Countries.

Almost in all developing countries, the technical knowhow of most internationally competitive industries are imported from developed countries. This demands for an immediate term need of being acquainted with this technical knowhow and also the ability to adopt the technology to suit local conditions & practices [3]. Hence, the immediate term university-industry linkage requirement would be to meet these needs. However, in the long-term, developing countries need to establish their own science & technology capabilities in order to be in par with global trends and to be internationally competitive.

In this regard, a major issue in developing countries is a serious lack in their research & development capabilities. If developing countries were to adopt the structural model of university-industry linkage of the developed world, they would have to first address the issue of lack of research & development capabilities during a transition period. In this scenario, international cooperation could play a vital role to enhance the research & development capabilities of the developing world in promoting university-industry linkage. However, for a more effective output, developing countries should focus on areas of their strengths and opportunities in line with government policies.

3 International Cooperation Center For Engineering Education Development (ICCEED) Of Toyohashi University Of Technology (TUT)

3.1 Philosophy & Structure of ICCEED

The demand for human resources that could sustain the technological advancement, global environment and economy on a global scale is becoming stronger and the ability of developing countries in meeting the bottom line of this demand both in terms of quality & quantity is becoming weaker. The government of Japan implemented the Official Development Assistance (ODA) in extending the frontiers of education through international cooperation as a means of addressing the above issue. In response to this initiative TUT established the ICCEED in 2001.

ICCEED aims to pioneer effective and efficient methods to foster researchers and experts who have potential and competitive power in the field of engineering in developing countries. The ICCEED has two divisions namely division of network & database development and the division of project development. It encompasses five priority areas indicated by research & development evaluation methods, construction of international cooperation network, research & development of engineering education projects, research & development of intellectual & human resource database and research on multilateral network in regional areas. The figure below (Fig. 3.1) indicates the organization structure of ICCEED.

ICCEED is devoted to international cooperation activities to foster skillful and sensible engineers in many developing countries. The Steering Council of the ICCEED is comprised of officials from the Ministry of Education, Culture, Sports, Science & technology, Ministry of Foreign Affairs, Japan International Cooperation Agency (JICA), Japan Bank of International Cooperation (JBIC), Association of National Colleges of Technology and other distinguished experts in order to provide advice on basic policy, activity plans and other relevant matters. In addition the Committee of Research Promotion Unit analyses the action plans decided by the Steering Council.

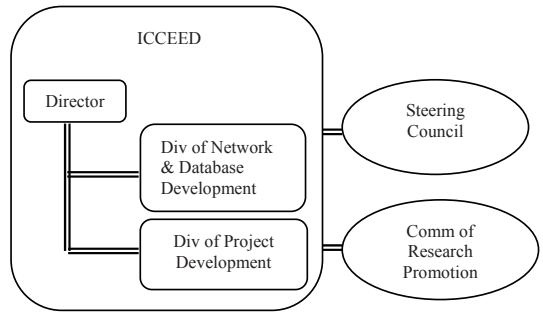


Fig. 3.1 Organization Structure of ICCEED

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3.2 Highlights of Past & Current Activities of ICCEEDD [4]

TUT has been vigorously active in international exchange activities since 1990 and as a result ICCEED was established in 2001 with the mandate of being the international arm of TUT. For example, Pathumwan Technical College Project (1993-2000), Thammasat University Expansion Project (1994-2001), Riyadh technical School of Electronics Promotion (1995-1998), Institut Teknologi Bangdung Reforms Support Project (1998-2000), Lampung University Support Project (1998-2000), ASEAN University Network/Southeast Asia Engineering Education Development Network Project (AUN/SEED-Net) (2001-2008), Higher Education Development Support Project (HEDS) (1990-2002). As for ICCEED, it has been active in evaluating the HEDS project, AUN/SEED-Net and more recently implementing engineering education development projects in Indonesia, Vietnam & Sri Lanka.

4 Case Of Sri Lanka

4.1 Current status of Institutional Mechanism for university-industry linkage

As for engineering education in Sri Lanka, 03 public universities namely University of Moratuwa (UoM), University of Peradeniya (UoP) and University of Ruhuna (UoR) offer 04 year internal degree programs in engineering for an annual intake of about 1100 students while the Open University (OUSL) offers a degree program through distance learning mode, all accredited by the Institution of Engineers Sri Lanka (IESL). Further, several study programs within these degree programs have received international accreditation status. In addition, few engineering degree programs are also offered by institutes and by those, which are private and affiliated to foreign universities. In addition to undergraduate study programs, UoM & UoP also conducts postgraduate programs mainly at Masters level (M.Sc & M.Eng) and M.Phil & Ph.D programs through research. These postgraduate programs are offered in the part-time and in the full-time mode providing opportunities for the candidates from the industry to enroll.

University-industry linkage has received acceptable degree of attention in engineering faculties in the most recent past. The faculties of engineering of UoM and UoP employ several mechanisms, which are similar in nature for the purpose of executing activities related to university-industry linkages. These mechanisms are undergraduate projects with some industry component, consultancy tasks by the faculty members at the request of industry, other outreach activities such as seminars, workshops, testing etc., Engineering Design Center of the faculty of engineering (EDC) and the University Industry Interaction Cell (UIIC) both established under Asian Development Bank (ADB) assistance. In addition, UoM has UNI-Consultancy Service (UNIC), which is the commercial arm of the university registered under company ordinance of Sri Lanka and UoP has the Center for Engineering Research and Postgraduate Studies (CERPS).

In addition, individual departments have their Department Industry Consultative Boards (DICB) and the faculties as a whole have Faculty Industry Consultative Boards (FICB) to ineract with the industry with reference to policy and curricula development matters. Both DICB & FICB are comprised of board members who are carefully selected among distinguished engineering professionals from the local industry. In conclusion, it is observed that the engineering faculties in Sri Lank, at present, have put in place several mechanisms related to university-industry linkage activities. However, it is also observed that the output of these mechanisms are still far from expected levels due to many challenges and issues faced by the engineering education system.

Among the challenges and issues faced by engineering education, the ones, which are related to university-industry linkages, are of importance. It is noted that universities are more oriented to knowledge & intellectual achievements and do not much exhibit a dynamic culture/environment of innovative research & development, targeting competitive use of knowledge for scientific & technical development. Further, it is noted that the transfer of knowledge through university industry links has not been very impressive compared to those in countries of similar social & economic development needs. In line with expenditure on tertiary education, funding for research & development is found to be relatively low. It is noted that the engineering faculties would have liked to have more patents, increase in number of industry consultancies & related income generated and more postgraduate work linked to addressing industry problems and related publications. Furthermore, the government being the key player in the tertiary education has not been able to be in par with the tertiary education expansion trends in the region.

Strengthening the university-industry link is an important aspect in engineering education in Sri Lanka. It is the most effective mechanism where both the university and the industry could benefit at the same time. The linkage would permit the flow of much needed funding to carry out research in universities either sponsored or collaborative nature, put into meaningful use of the knowledge & skills of the academics, possibilities of innovations of value to both university & industry, make use of the resulting industry experience back in the teaching programs & postgraduate research and national level contribution of local technology development.

In the national perspective, it is observed that many initiations are taking place and efforts are being consolidated among main stakeholders such as relevant Ministries, Science & Engineering universities and Industry Associations with he prime aim of strengthening the University-Industry-

mmeybodi@aut.ac.ir

Government linkage related activities in view of developing the local science & technology base.

4.2 Description of Strategy with the ICCEEDs Cooperation

University-industry linkage activities are not only a practice at TUT sponsored by the Ministry of Education, Sports, Culture, Science & Technology (MEXT) program of International Cooperation Initiative in Education but quite common in universities in Japan. Tokai area where TUT is located has a variety of industries dominated by automobile industries and TUT has good experiences of joint research activities with these industries. ICCEED has been engaged in the implementation of international cooperation projects, dispatching experts, accepting trainees and organizing seminars for fostering the development of engineering education.

In this scenario, ICCEED has started a new project, which aims at introducing methods and experience of university-industry linkage in Japan in strengthening university-industry linkages in developing countries. A pilot project targeting the Faculty of Engineering of University of Moratuwa (UoM) in Sri Lanka is being implemented with the hope of extending the success of the model to few other developing countries. The objectives of this project are (1) capacity building of university-industry linkage coordinators, (2) development of a monitoring & evaluation (M & E) mechanism of university-industry linkage including intellectual property aspects (3) development of a sustainable mechanism of generation and management of a research fund.

ICCEED has conducted a preliminary needs assessment survey of industry in Sri Lanka. In line with priorities & policies of the Ministry of Industrial Development and the impact potential, 05 thrust areas for university–industry linkage activities have been identified. These thrust areas are from the Globally linked and Policy linked industries as defined by the Ministry of Industrial Development. They are Textile & Apparel, Ceramics, Tea & Rubber representing Globally linked and Die & Moulding, Electrical & Electronic components representing Policy linked industries. Their value addition potential, use of local resources and contribution to the GDP have also been considered in the selection. Based upon the result of survey, ICCEED will organize seminars in Sri Lanka and Japan for selected participants from UoM. In the seminars in Japan, trainees will have opportunities to visit Japanese firms in order to observe practices of university-industry linkage together with the matters related to intellectual property rights and management of technology. A certain level of capacity mobilization of the trainees is envisaged enabling them to understand the suitability of the models used in Japan as appropriate to Sri Lanka. Finally trainees are expected, with the assistance of Japanese experts, to develop an action plan to achieve the project objectives. Meantime, a detailed survey will be carried out to identify the specific needs of the each of the thrust areas. During the implementation stage some projects will be selected from thrust areas and will be monitored for performance and evaluate the success of the model to be able to extend to few other developing countries. The Figure below (Fig. 4.1) indicates the organization structure of the pilot project.

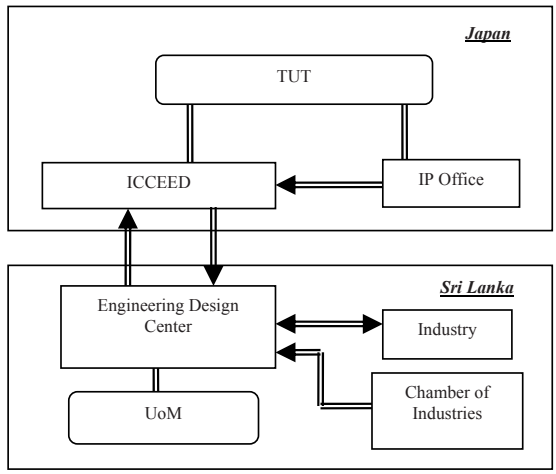


Fig. 4.1 Pilot Project Organization Structure

5 REMARKS

Universities in Sri Lanka are more oriented to provide theoretical knowledge & intellectual achievements and provide fewer opportunities for the fresh engineering graduates to develop critical thinking & skills oriented towards technology development. Moreover, the transfer of knowledge through university industry links has not been very impressive compared to those in countries of similar social & economic development needs in terms of standard criteria.

This pilot project aims at strengthening the existing mechanism of university-industry linkage at the UoM through one of the international cooperation activities of ICCEED. From the UoM perspective, the project is looking forward for outputs of capacity building of university-industry linkage coordinators, development of a monitoring & evaluation (M & E) mechanism of university- industry linkage activities and also the development of a sustainable mechanism of generation and management of a research fund. It is also expected to increase the number of patents and industry related research projects resulting from the momentum gained by the project. Finally based on the success of the pilot project

mmeybodi@aut.ac.ir

it is expected to extend the model to few other developing countries.

From the perspective of TUT, Institute is interested in offering opportunities to smart students from abroad. It is observed that the international students not only stimulate Japanese students but also contribute to improvement quality and efficiency of research in the university. Out of 2000 students in TUT, there are about 180 international students and these international students contribute to improvement of quality of education at TUT.

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mmeybodi@aut.ac.ir

Issues in Mobile Learning in Ghana

Richard Millham
Catholic University of Ghana

Abstract: *Ghana, a sub-Saharan country, faces a crisis in trying to keep its population in step with a technologically-changing world. With limited funding, a dispersed population, and a shortage of lecturers, the ability to manage lifelong learning, as required by a rapidly-changing technological world, for its populace is difficult. In this research-in-progress paper, we propose distance education, notably mobile learning, as a solution to the need of lifelong learning and to the constraints of the existing educational institutions. We also examine some of the issues surrounding distance education. A survey of Ghanaians as to their preferences for curriculum and training in this area is briefly presented.*

Introduction

In this paper, we will briefly look at addressing a pressing need in Ghana, lifelong learning as a means of creating a technologically-enabled society, as well as providing an appropriate medium for this type of training. Because of the lack of local expertise and a dispersed population base, distance education was selected as the best means of providing this training. Issues with distance education, in particular mobile learning, along with possible solutions are discussed. Finally, a survey of Ghanaians as to their preferences for curriculum and training will be briefly presented.

Background

Given an increasingly technologically-changing world, many employers in sub-Saharan Africa at present require proficient computer literacy skills for their new employees. These employers, along with their governments, view computer literacy and effective computer utilisation as a means to enable the production of "knowledge-based" industries and, thus, for combating high youth unemployment [16].

However, education within Ghana is ill-equipped to provide this type of training. Ghanaian education, based on the residential model, suffers in general from poorly-equipped facilities, lecturer shortages, under funding, outdated and irrelevant curriculum, and overcrowding [15]. Distance education is seen as a solution to the problems of under funding and overcrowding for residential education [1]. Furthermore, with an increasingly changing society, learning has changed from a traditional short period during a young adult's life to that of lifelong learning with the need to collaborate with others [10].

Given students' irregular schedules and the constraints of existing educational institutions in Ghana, distance education, particularly computer-based networked, is considered advantageous. The advantages of computer-based networked distanced education include a sense of presence when interacting online with

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 437–441.
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mmeybodi@aut.ac.ir

others, improved learner support, asynchronous learning, and global access to training resources and teachers. Another advantage of computer-based distance education lifelong learning is the availability of content management systems that allow culturally-specific material to be edited or removed for a new audience [17] [12]. The need for relevant, cultural-specific course curriculum is especially important in Africa. Distance education, and its models, is a Western social, cultural, and educational construct that has been imported into Africa quite recently [1]. There is a strong need to "Africanise" the distance education curriculum in order to factor in and adapt to the diverse needs of a sub-Saharan African audience, whose language might be very different from the language of instruction [6].

Given the advantages of computer-based, networked distance, a prerequisite for this distance education is computer literacy. In order to address this need for computer literacy, the government of Ghana has provided a curriculum for computer literacy training for teacher training colleges and senior secondary schools in Ghana. Given the time for these changes to take effect and the small proportion of the populace that attends senior secondary school, e-learning and other computer learning centres for the rest of the population are to be available. However, these centres are very few in number and any e-learning centres, other than the University of Ghana and GIMPA which are based in the capital of Accra and which provide native content, are based outside the country [10].

Another real problem with computer learning is a lack of infrastructure in sub-Saharan Africa. An example, Ghana has poor DSL access and long customer connection times, despite high consumer demand. Consequently, the sending of training materials via satellite is stymied by this situation. As a solution, Internet Ghana has introduced wireless DSL access but this access will first cover only the major cities [9]. Remote villages and smaller towns lack access to power or suffer frequent power outages in addition to limited or no Internet access [7]. Although many private computer literacy training firms exist locally, because of the lack of any standards, this computer literacy training has questionable value [7].

Mobile Learning – a Solution?

Computer-based education requires access to a computer, which may be impractical at times such as during a student's commute. Mobile technology, which allows access to computer-based learning anytime, may be a solution [17] [12]. Another important factor is the explosive growth of mobile phone customers in Africa. Africa had an estimated 192.5 million mobile phone users in 2006, up from just 25.3 million in 2001, according to figures from the U.N.'s International Telecommunication Union. [3]

Yamaguchi states that mobile phone's advantages are in its portability and its affordability [20]. In Africa, mobile learning is a way of dealing with the challenges of poor connectivity, frequent power disruptions, and low PC availability and is strengthened by the enormous spread of mobile phones and by the vigour and talent of the mobile phone networks [18].

However, computers handle visual, sound, and textual information much better than that of a mobile phone [20]. Other disadvantages of mobile phones include reduced screen sizes, limited audiovisual quality, virtual key-boarding, one-finger entry, and limited power. Further disadvantages of mobile phones include their potentially limited nonverbal communication, limited message lengths, a lack of cultural context, and possibly limited social interaction. Although mobile learning is moving to visual content, mobile phones face problems accessing visual content when they do not have online access. One possible solution is to cache online content while con-

mmeybodi@aut.ac.ir

nections are available but this solution would not be possible in areas where there is no Internet connectivity [4].

Another issue is that the cost of a mobile phone call is more expensive in developing countries – 26 cents per minute for daytime calls in the Democratic Republic of Congo compared to 7 cents per minute to users in Germany. In contrast, the cost of sending a SMS message, because of its condensed content and short transmission time, is much less. In poor rural areas, the higher cost of building networks in areas without electricity or good highways and the high cost of security, to prevent theft of antennas, must be borne by the cell phone subscribers [19][5].

Faced with the issue of limited visual capabilities of mobile phones, particularly the older mobile phone models in common use in Africa, concentration has focused on SMS (textual) messaging for training. Most older mobile phones have SMS capability but lack the ability to receive other types of visual content such as Web pages or animations. The BBC World Service's Learning English section offers English lesson via SMS in Francophone West Africa. The goal is not only to provide non-English speakers with language lessons but to engage new kinds of learners (ex: young, disabled) at a time and place of their choosing. (Godwin-Jones, 2005) It has been suggested that portability and immediacy, rather than localization, are the important motivating factors in mobile language learning.

Leinonen provided both instructional material on HIV/AIDS for Grade 11 students and the ability to query Wikipedia and receive query responses all through SMS. They found in their study that students were able to use SMS well even though they were not ICT literate. [11] Attewell, in conjunction with Albatros, used SMS as a teaching tool for Italian lessons. Reference material was first provided and then a quiz on this material was sent to the learner via SMS. The learner, after responding to the quiz, would then receive feedback on their response [2].

Dearden and Traxler propose the use of SMS to deliver course material, feedback on submitted quizzes and assignments (sent in by SMS), and to provide a forum for discussions among students. The provision of course material ("the didactic model") is not remarkable but the ability to use SMS to provide a collaborative learning environment for students promises great possibilities. Rather than rely on top-down broadcasts of material, interaction can occur in local, decentralized groups on a peer to peer level [5]. Traxler noted the use of SMS to train teachers in Kenya [18].

As an example of the use of SMS in a developed country, Cheung used SMS (Simple Message Sending) in a macro-economics class to teach students about markets and models. Students were given a hypothetical macro-economic situation to which they were given a limited number of options as a solution. Students would SMS their answers to the university where these answers were recorded and analysed [4]. In Australia, Italian learners received vocabulary words, definitions, and example sentences via SMS in a regularly scheduled delivery and feedback was given in the form of quizzes and follow-up questions [4].

Survey

Traxler recognizes that mobile learning needs vary from country to country and from one group to another [18]. In order to determine the needs and issues surrounding distance education in Ghana, a survey was conducted of 100 people from diverse groups in several different regions of Ghana.

Although distance education courses are available to Ghanaians from foreign countries, the survey revealed that the cost of such courses is too high for most Ghanaians to

mmeybodi@aut.ac.ir

afford. The one respondent that is taking such a course had difficulties with the current speed of available Internet connections. Consequently, he was forced to go to an Internet café during the night, when customers were few and the Internet speed consequently adequately quick, in order to access his course materials [13].

In terms of desired curriculum, 80% of the respondents favored computer literacy training, followed by public health information. Because over 75% of the phones surveyed lacked Web-based and Java animation capability, SMS was the only realistic medium for distance training [13]. The majority of those surveyed felt that training, via SMS, would not be boring, despite the lack of a good visual display, provided that the basic information is there. This majority also felt that besides providing information, quizzes on the material and feedback, using SMS, should be provided in order to facilitate their learning [13]. One potential problem might be in conveying complex, graphic computer literacy concepts through a one-dimensional textual medium of SMS. If this conveying of concepts through SMS is not feasible, SMS could provide an excellent supplement to printed graphical materials sent out to students.

Besides iterating Yamaguchi's points on mobile phone's limited functionality and small screen size, the respondents also brought up other issues. Mobile phones, although very popular, are easily stolen. SMS transmission, if not received within 24 hours by the recipient, is lost. Given Ghana's frequent power and mobile network outages, the possibility of lost SMS messages, and its associated loss of training material, may be an issue [13].

Future Work

This paper briefly outlines some of the issues of distance education and mobile learning, particularly in Ghana. A small survey is given that outlines some of the preferences of the Ghanaian population in terms of distance/ mobile learning as well as some of the problems inherent within them. Future work would include developing a SMS-based computer literacy programme, with frequent quizzes and feedback, that would be suitable to a Ghanaian context and then, through feedback of students, evaluate its effectiveness. Once the effectiveness of such a programme is established, the programme can be expanded to include a number of diverse fields such as entrepreneurship and business management skills for the educationally-disadvantaged.

Conclusion

This paper quickly explores some of the issues of distance learning, particularly mobile learning in Ghana. Because of the explosive growth of mobile phones and networks and the slower growth of public computer access along with frequent power outages and limited Internet access, mobile learning is advantageous as a means of distance education. Although mobile learning has the capability of rich animated visual content and Internet access, limited Internet access and the shortage of phones with such features means relying on SMS for transmission of training material. A preliminary survey has been conducted from which a small pilot project will be based in order to gauge the effectiveness of such a mobile learning programme, through SMS, in a particular developing country.

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mmeybodi@aut.ac.ir

A First Investigation for Reducing E-Learning Environment Complexity by Multiscale

Rim Drira [1,2], Mona Laroussi[1,2], Alain Derycke[2]
[1] Riadi laboratory, ENSI campus de la Manouba 2010 TUNISIA
[2] Lifl laboratory, Sciences and Technologies University of Lille 59655 Villeneuve d'Ascq cedex – FRANCE
rim.drira@riadi.rnu.tn
mona.laroussi@lifl.fr
Alain.derycke@lifl.fr

Abstract— **We present in this paper the results of our study concerning the application of some techniques from complex system field (multiscale) in e-learning research. The motivation for this innovative inquiry is that we still think that complex problems related to e-learning remain in components, when they are usually in the relationships between them. We demonstrate how a complex system perspective to e-learning is promising to bring a solution for this problem.**

I. INTRODUCTION

The development of a widespread digital infrastructure to support a range of learning activities coupled with the growing use of information technology within education has highlighted the raising importance of e-learning.

An e-learning environment (ELE) is made up of many components that interact at multiple layers of organization and at different time scales. It does not represent only a technological infrastructure but it represents a socio technical system resulting from the use of this infrastructure by human actors [31]. The multiplicity and diversity of interactions among ELE components are essential for the e-learning environment efficiency and show its complexity.

In social, physical and biologic systems, there has been growing interest in developing effective approaches to study "complex systems" since scientists have become aware that many issues can be investigated only by thinking about relationships.

In the e-learning field, we believe that it is both necessary and interesting to infuse a complex system perspective to manage complexity of an e-learning environment.

This paper does not pretend to bring "ready-to-use" solutions in this area. However, we aim first to point out some important issues that will be more useful in the future. Second, we propose a study of the application of multiscale in eleaning environment.

This paper is organized as follows: in section 2, we give first an overview about complex systems and then we situate e-learning environment complexity. A state of the art synthesis of multiscale study in different fields of research is provided in Section 3. The application of the multiscale in e-learning is presented in Section 4 before a conclusion.

II. E-LEARNING ENVIRONMENT AND COMPLEX SYSTEMS

We begin by presenting basic principles of complex systems. In light of this presentation, we discuss ELE complexity.

A. Complex system

First, it is necessary to distinguish complicated systems from complex systems. For example, an aircraft is complicated; it contains many parts with many relationships. These relationships are known or knowable. Therefore, if we take an aircraft apart into its various components and reassemble it, we get the same thing: the whole is the aggregate of the parts. However, if we try to take a complex system apart, or even subject it to analysis, then it changes as a result of the exercise, and changes again as it is put back together.

Maxwell [29] defines complex systems to contain many components and layers of subsystems with multiple non-linear interconnections that are difficult to recognise, manage and predict. Bar Yam [1] considers a complex system as a system with interdependent parts. Interdependence means that we cannot identify the system behaviour by just considering each of the parts and combining them. Instead, we must consider how the relationships between the parts affect the behaviour of the whole. Many other definitions were found in the literature. The common principle in all these definitions is the interdependence between system parts that gives rise to collective behavior (emergence phenomena). Emergence is what parts of a system do together that they would not do by themselves (See [2] [3] for detailed discussions about emergence). We think that this concept will be more important in next elearning systems based on Web 2.0 [30] because of communal dynamics and the openness aspect of an ELE.

Actually, complex system concepts are widely used in different fields like biology and sociology where they proved their efficiency contrarily to the reductionism approach.

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In this context, can complex system concepts do so much in e-learning?

B. E-learning environment complexity

Some authors like [4] [5] consider the ELE as complex based on the huge number and heterogeneity of its components. These arguments are certainly factors of the e-learning environment (ELE) complexity. However, interdependence between components is the most important feature (See section II.A) that must be confirmed.

According to many researches dealing with ELE (such as [6] [20]), there exist many relationships between ELE components. Peraya, D., Jaccaz, B., Masiello, I., and al [6] identified four interrelated families of variables involved in an ELE: structural variables; "acting" variables related to actors in the environment; individual variables and variables related to the field. For a better understanding of the textual description given by [6], we elaborate the UML class diagram showed in figure 1.

As demonstrated in the class diagram, there exist relationships of different natures (explained by the association names) between the four variables. For example, each structural variable mobilize different actors. The role and the function of each one of them depend on his individual features. Several field variables are involved in each structural variable and are related to individual features.

A crucial question should be asked at this level: Do these relationships mean complication or complexity?

Because an ELE is not necessarily equal to the sum of its parts, ELE is complex and not complicated (See section 2.1). The main factor of this inequality is the importance of actors (a core component) and their influences on all the other components. In fact, with any community composed of human beings (virtual or otherwise), it has been showed [7] [8] [9] that interaction between them leads to a highly complex network of communications that produce the unexpectedness of the system behavior.

Following the insights stated in the last paragraphs, we suggest a new definition for ELE [28]:

An ELE is a complex system formed by a set of interdependent and heterogeneous components organized in space and time in order to satisfy a learning goal. More specifically, we see ELE as a complex system composed of:

– A set of actors (individual variables and relationships)
– A technical infrastructure composed of software and hardware

A learning content encompassing elementary learning resources and a pedagogical model.

By this new perception of ELE, we do not pretend to give solutions for specific problems but we try to introduce a new way of handling complex issues related to ELE and to open up new research issues.

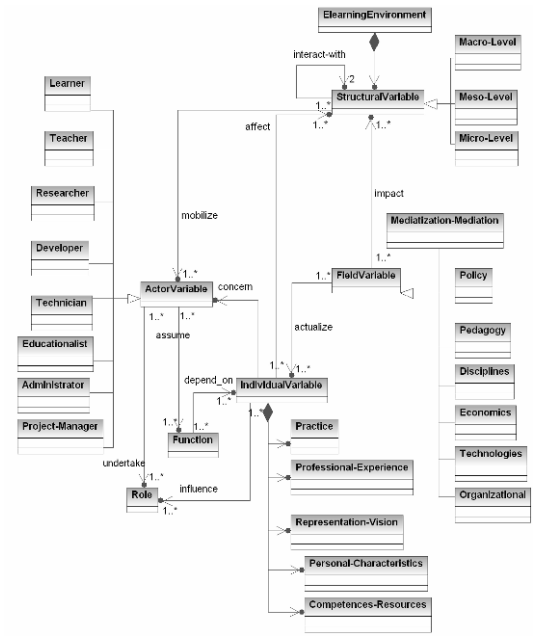


Fig. 1. UML class diagram of ELE

The following topics should be investigated in order to define a common ground that could be used to integrate advances of complex systems studies in the field of e-learning:

– It's crucial to study how advances of complex systems can contribute to the enhancement of both ELE design process and learners learning process.
– The simulation of an ELE and the prediction of emergent phenomenon is an issue of great importance that still needs exploration. However, in the context of complex systems, a great work has been done. Therefore, the study of the reuse and adaptation (if necessary) of the work done in complex systems field could be fruitful and hasten research results.
– Complex system concepts and tools are numerous and varied. It could be useful to benefit from these tools in e-learning research and even adapting them to the e-learning context. In fact, in the field of complex systems, concepts such as multi-scale, interdependence, emergent patterning, agent-based modelling, dynamical attractors, deterministic chaos, information flows and constraints, system environment interaction, developmental trajectories, fitness landscapes, and self organization are becoming key tools for qualitative reasoning about real complex systems as well as quantitative modelling and simulation [1] [9].

mmeybodi@aut.ac.ir

Multiscale is one of the most important concepts in the study of complex systems. It is used mainly for the study of interactions between scales of a complex system. In our ongoing research, we are focusing actually on the use of multiscale in the e-learning field.

Before presenting the result of this study, we give in the next section our synthesis of the state of the art of multiscale: definitions and use cases.

III. The Multiscale: Overview

Researches dealing with the multiscale concept are various and numerous (See for example [10] [11] [12] [13] [14]). Multiscale give good results in the resolution of various problems related to several disciplines. However, a general definition of multiscale does not exist. The state of the art of multiscale remains dependent on its application field.

Let's define the scale concept first; then, we propose definitions for multiscale and MSM as synthesis of their state of the art.

Scale: In the literature, the scale was not perceived in the same manner. In fact, a wide spectrum of definitions and synonyms (such as view, level) has been identified. As result, new expressions (multilevel, multiview) sometimes considered synonyms to multiscale were used [16]. White [13] prefers to use "view" instead of "scale" and multiview instead of multiscale. Bar Yam [9] defines a scale as **the size of a system or property that one is describing**. For example, from the smallest to the largest, we can consider the following scales of the universe: an elementary particle, an atom, a molecule, a cell, a person, a city, a planet, a galaxy. Bar Yam proposes another definition of scale: **the precision of observation or description**. For example, if we use a zoom lens to look at a person, details are perceived by increasing precision from a dot, to limbs, to face until atoms.

Much other scale definitions can be found in the literature but Bar-Yam gave the most general ones.

Multiscale: We propose to define the multiscale as a methodological theory supported by several techniques-often mathematical- that are dependant on the application field. This theory allows object or system examination, especially complex ones, at different scales and the exploration of links between them.

We note that multiscale does not mean many scales (multi + scale); but the key principle is the exploration of links between them. Therefore, the use of multiscale is convenient when **it is requested to handle different scales of a system together**. For this reason, multiscale is used particularly in the study of complex systems. This can be done by Multiscale modelling.

Multiscale modelling (MSM): we define MSM as the modelling of object at several scales. The MSM can lead to more accurate understanding of objects and their related phenomenon. It is creative when models of different scales are integrated in coherent way. This integration of scales is one of the key features of MSM that allow reaching relevant results that cannot be accomplished without this integration.

Examples of multiscale use for complex system study are numerous and involved in several disciplines.

In the field of simulation of material, Legoll [12] uses multiscale in order to understand the impact of phenomenon description given at the molecular scale of material (the microscopic scale) on the continuum scale of material (a macroscopic scale).

System Level Science [10] is a multiscale approach that allows controlling the complexity of a system. It consists on the integration of different sources of information concerning sub-systems forming a complex system in order to understand entirely the system. This modelling allows the simulation of system behaviour and phenomena prevention (for example, seismic prevention [10]).

In the field of human body modelling and simulation, the biological complexity is characterized by the intimate connection that exists between different length scales; from the nanometer (length scale of molecules) to the highly structured meter scale of the whole human body. For example, subtle changes in molecular structure as a consequence of a single gene mutation can lead to catastrophic failure at the organ level. Thus, interpreting the interactions that occur across the length scales from genes and proteins to cells, tissues, organs, and organ systems requires a multiscale mathematical modelling framework [11] carried out by the Physiome project (http://www.physiome.org.nz/).

IV. Multiscale in ELE Research

Compared to other fields, we believe that multiscale can guide dealing with many issues in e-learning. For these issues, links between scales of the ELE have a core importance in their analysis and resolution. Examples of this kind of issues will be given in next paragraphs. Before this, the following questions need to be answered:

Which are the main steps necessary to perform a MSM of a system? Are they the same steps in the context of ELE?

With analogy to researches investigating MSM, the main steps to a multiscale application are the following: the process begins by attempting to define the relevant scales to be considered. The second step concerns determining *link objects* between scales.

The first step of MSM is the most important one due to its great impact on multiscale study results. In this step, we try to answer the critical question: which scales are relevant for a multiscale study of a system?

Scales are specified depending on the research needs of the topic under study. The available information about the system plays also an important role in the scales choice [17]. Furthermore, these scales can be selected differently according to author's perception of the system. New perceptions can arise from changes in the interpretation of scale.

Link object is an expression of relation between scales. For example, when the link object is about deducing a scale model from another, (like in [14]) the link object corresponds to the transition procedure between them.

In the remainder of this section we present first results of multiscale study of an ELE.

First of all, we affirm that it is not feasible to find a sufficiently general MSM enclosing all scales of an ELE because of its highly heterogeneous nature and

mmeybodi@aut.ac.ir

complexity. However, we can determine several multiscale models expressing different views of ELE. For this aim, we propose to introduce the concept of meta-scale.

Meta-scale expresses a perspective of a system observation. Examples of meta-scales we depicted for an ELE are disciplines implied in ELE's study, structure, components, Actors View of ELE, time, space, life cycle (See figure 2). For every metascale, scales can be determined (see figure 2). These scales can also be seen as meta scales and a multiscale study can be realized for each one: we call this process recursive multiscale.

With each metascale, we obtain a different view of ELE. Several multiscale problems (problems for which multiscale can be used) are revealed.

For example, if we choose the metascale discipline, scales are the different disciplines involved in ELE engineering: Social science, HCI (Human Computer Interaction), instructional design, etc. (see figure 2). At the scale of social science, the social aspects are modelled. On the other side, at the scale of HCI, aspects related to learning content presentation are modelled. For these two scales, the integration of social aspects related to collaborative learning in the HCI of an ELE is a multiscale problem; several link objects can be determined.

A multiscale problem of great importance in the context of ELE flow out from the view related to lifecycle: the study of relationships between design time scale and run time scale. For example, a link object can be created to control the realization of learning objective between design and run time scales. At design time, a teacher prepares his content with respect to a learning objective. At run time, the accomplishment of this objective is uncertain. The role of the link object is to help the realization of the objective at run time and to give feedback to review design time choices if necessary.

Another multiscale problem is the creation of link objects between the micro, the meso and the macro scales of an ELE. A discussion about these scales and relationship between them can be found in [6].

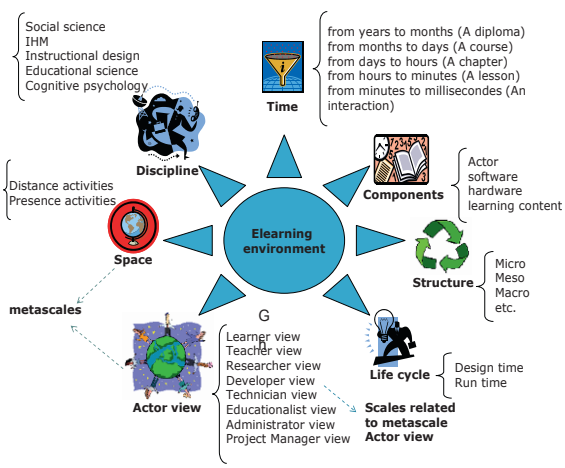


Fig. 2. Examples of metascales and scales of an ELE

Many other problems for which multiscale can be efficient exist. The results that we have presented until now shows that much multidisciplinary work must be done in order to define relevant link objects between scales and metascales.

We focus actually on investigating some problems related to learning resources which is our main research team's field of study. We treated in previous contributions several issues related to content adaptation [24] [18], the use of Web services [23], adaptation to context in mLearning [22], e-learning standards adaptation [19] [21] [25].

From our previous researches [18][19][21][24][25], we have noticed that learning resources are treated at several scales and that scales are usually considered independently one from each other when we design the hole content.

The scales of learning resources that we consider, with regard to a content engineering based on activity are: task, activity, scenario, learning unit. The Link objects between these scales that we are actually conceiving can treat several topics: time modeling, check of scenario characteristics [27] between design and run time, etc.

V. Conclusion

This paper proposes a new way of thinking an ELE as a complex system. The complexity of an ELE was discussed in light of a rapid presentation of main complex system principles. Complex systems concepts provide a new unity of approach to many different problems. They are widely used in different fields like biology and sociology where they proved their efficiency. Important research efforts must be done in order to profit from these advances in e-learning research. The main topics that must be studied were specified in this paper. The study of reuse and adaptation if necessary of system complex concepts is among these topics.

Multiscale is the complex system concept that was studied in detail in this paper. Initially, we have provided a state of the art synthesis of multiscale: key concepts definitions, cases and methods of use.

Then, we have showed several multiscale problems related to ELE and we have specified the problems which we are studying actually. Furthermore, we have determined many multiscale views of an ELE and explain why it is not possible to elaborate a general multiscale model of ELE.

Our ongoing research concerns a multiscale modeling of learning resources. The scales under study are: task, activity, scenario, learning unit. In a next paper, we will detail our multiscale approach to learning resources engineering. Our approach is based on MDA (Model Driven Architecture). It allows teachers to conserve their engineering practices and manages links between scales according to multiple criteria (Actually, time modeling and check of scenario characteristics [27] are considered).

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mmeybodi@aut.ac.ir

Virtualized Computer Labs and the Software Tools to Make It So

Ronald Mashburn
West Texas A & M University
rmashburn@mail.wtamu.edu

Abstract

A crucial part of the teaching of computer courses is the examination of and experimentation with the technology. Most courses are quite expensive and require access to lab equipment that most students don't have. There are many freely available platforms (e.g. Linux) for this purpose. Because of this, I have explored many simulation, emulations and tools for computer labs. These modules are available to students as part of their experimentation with computers. This paper describes the way I use these tools in my online computer classes.

Kēywords: Computer labs, virtualized, servers, simulation

Introduction

Despite the tremendous success in the development of distance learning and its anticipated future, one major challenge remains that leaves some specialized fields of education far from being ready to go on-line. In engineering programs where laboratory sessions are indispensable, students would not be able to complete degree requirements without attending the real campuses where real lab facilities are provided. The primary solution to this challenge has been software simulations. While the comprehension of study materials can only be a question of time for any student, the student can learn through easy-to-use tools. However, the problem is not so easily amenable when the student's understanding of the experimental concepts through the simulation software material is the paramount goal. Many institutions have recognized the challenge of offering lab courses over the Internet and have spent significant efforts to overcome this weakness. I have explored many different methods to place laboratories on-line. Among the methods that were explored, simulation identified as the best alternative, because it is highly portable and cost effective. Simulation software is designed for the purpose of bringing the laboratory facilities to the door of the student. Constant improvement has been made in the software to make the whole experience nearer to reality. TestOut [1] is simulation software that is very appealing. TestOut has involved the efforts of developing simulation software for certification testing the student. The software has-a very user friendly interface, which is designed to guide a student step by step through the process allowing more time to complete task. The software available from Course Technology in the form of SAM [10] has met these requirements. Simulation software is seen as one way of imparting practical knowledge by allowing the student to conduct experiments on the computer by simulating all the steps, which a student would take in a real laboratory of computers to perform the configuration steps.

The Virtual Classroom

West Texas A & M University (WT) developed an online content management system called WTClass. WTClass [16] is the course management system that was developed to provide WTAMU students and faculty with a high quality distance education delivery system. WTClass was first developed in-house by the WT in house programmers using open-source code and it was called WTOnline. The first WTOnline class was offered in the summer of 1997 and had 24 students. Since then the numbers of classes and students has expanded to 152 courses and 5,083 students in the spring semester 2005 while the WTOnline interface and tools have continued to evolve in response to faculty and student needs. WTOnline's user-friendly interface contains a variety of electronic learning tools that enable students and faculty to collaborate and develop knowledge in a learner-centered environment. Some of the tools that make WTOnline effective are the electronic bulletin board, online chat rooms, a file repository, electronic exams, an electronic grade

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 447–452.
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mmeybodi@aut.ac.ir

book, an internal mail system and a built-in web page editor. Students logging into WTOnline are able to access their courses as well as information about student services. WTOnline training classes are held throughout the year for faculty who wish to develop online classes. WTOnline was recently renamed WTClass and the software which was produced in-house has since been replaced with a commercial package called Angel.

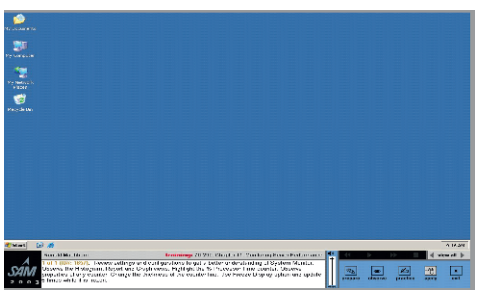
WTClass will be used to deliver the classroom concepts for my courses. WTClass has the management tools that compare with other online delivery tools such as WebCT and BlackBoard. WTClass does not provide a mechanism for labs in the computer classes. As it is practiced today, WTClass focuses on developing and supplying education materials via the Internet in the form of books, instructional materials, visuals, explanations, and other forms of traditional and modified online materials. Course content is continually updated to increase the effectiveness of learning. Interactive group discussions, collaborative class projects, and on-line help are being offered to give the student the feeling of being in a traditional classroom. The teacher assigns work in much the same manner as assignments are given in an on-campus to gauge the extent of learning by the student. Fundamentally, the method of teaching adopted in virtual education can be classified as synchronous or asynchronous in that each approach offers a unique advantage. Synchronous teaching contributes to collaborative learning through joint problem solving scenarios and can be used in threaded discussion through active participation of the guide or teacher. Asynchronous teaching frees students from the anxieties associated with group learning and permits self-paced study through repetition. Both modes are popular among the students and universities and are used extensively. This realization that distance education needs no on-campus facilities gave rise to virtual classrooms. The term “virtual” indicates that the university may or may not have an existing campus course. Thus, virtual classroom have emerged as an equally acceptable alternative to conventional courses. If students and teachers maintain proper interactivity, the concept of the virtual classroom is likely to be successful.

Creating a Virtual Computer Lab

Despite the tremendous success in the development of distance learning and its anticipated future, one major challenge remains that leaves some specialized fields of education far from being ready to go on-line. In engineering programs where laboratory sessions are indispensable, students would not be able to complete degree requirements without attending real campuses that provide real lab facilities. The primary solution to this challenge has been software simulations. While the comprehension of study materials can only be a question of time for any student, the student can learn through easy-to-use hands on experiences. However, the problem is not so easily amenable when the student understands of the computer concepts through the required technology and material is the principal goal. Many institutions have recognized the challenge of offering lab courses over the Internet and have spent significant efforts to overcome this weakness. I have explored different methods to place laboratories on-line. Among these schemes, Simulation Software has been identified as the best alternative, because it is highly portable and cost effective. Simulation Software is designed for the purpose of bringing the laboratory facilities to the door of the student. Simulation software is seen as one way of imparting practical knowledge by allowing the student to conduct experiments on the computer simulating all the steps, which a student would take in real laboratory of computers while performing the configuration steps. Constant improvement is made in the software to make the whole experience nearer to reality. The simulation needs to visually look and operate as near to the real operations to be considered for use in the virtual networking lab. I first looked at Boson NetSim [5.]. Boson NetSim is a simulation tool in training CCNA and CCNP candidates. The Boson Virtual Packet Technology used in the Boson NetSim is offered in a number of different ways depending on your budget and certification needs. I liked the network simulations in this product for my data communication course. It had configuration of routers, hubs, switches and gateways. All simulation was done at the prompt level. It allowed using netstat, ping etc. commands to test the configurations. It had an easy way of constructed labs and configuring activities for students to use. All labs and configurations were based around the Cisco equipment and certifications. The next part of

mmeybodi@aut.ac.ir

networking course needed implementation and configuration of servers. I noticed on the Microsoft web site the TechNet Virtual Labs [6.]. This was software simulation of certain task to untaken for management and configuration of Microsoft Servers. The labs were of the upper level material and were directed towards more of the Microsoft Certifications. The price was right, free with limited time use. The software had no student management material. It was just for training individuals to take the certification test. This got me looking for other like material with similar functionality with more varsities. I looked at TestOut.[1.] TestOut has involved the efforts of developing simulation software for certification testing with student-friendly software, which is designed to guide a student step by step allowing more time and explaining the results. Unlike the Microsoft TechNet Virtual Lab this software would track student's progress and give performance and knowledge level test. The first version that I was introduced to was delivered on CD and was mainly for students to use that were seeking certifications. It did come in a wide variety of areas including Linux, Security, and Windows. The software was quite expensive for students to purchase and there wasn't an economical site license. I then discovered that TestOut had ties to Thompson Publishing[7.]. I found this software available from Course Technology[2.], a division of Thomson Publishing, in a product referred to as LabSims. This software was more in the pricing of course material used by the college. The software did require individual ownership and/or installed on individual computers on the school network. I needed something that could be delivered web based. So come forth a similar working product offered by Course Technology named SAM[10]which has met these requirements.



SAM Networking training screen

The first version of this course content delivery system has the Microsoft certification requirements around the Office products and Windows 2003 server. Considerations of expanding this to Networking +, Linux and maybe even Netware are being explored. I've used this virtual lab material for my introduction computer application class and my networking course which were delivered online using the WTClass. It has been well received due the ability for students to still get hands-on experiences without going to on campus labs or owning their own equipment. I like the student management tools that this system gives me. I can monitor student's progress during training. I can construct both knowledge based task as well as task based exams all graded by the system.

Remote Labs: Another Solution

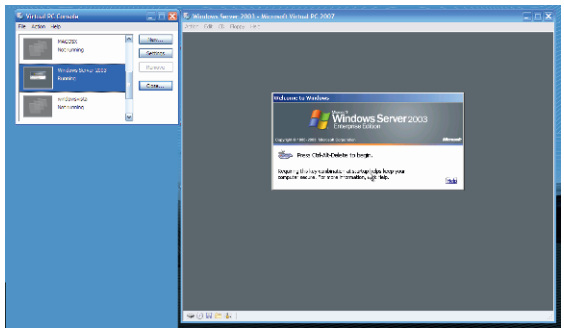
A real laboratory experiment etches firmly on the mind of the student for which there can be no substitute. The mistakes that a student makes during any experiment helps that individual to more clearly understand the concepts behind the experiment. These mistakes become valuable lessons that are unlikely to be lost with the passing of time. Involvement of body and mind in a real experiment yields rich dividends of knowledge gained by the experimenter. Teaching a student all through the course by simulation studies can, perhaps, make the student meet the requirements of the course and enable him to complete it satisfactorily from the point of view of the university that offers the course. At the conclusion of the course, however, we only have a student who is completely incompetent in repeating the experiment in a real laboratory. Regardless of the diligence that goes into to software design, the element of reality will be missing, the student becomes a spectator. In the field of practical studies, there can be no prominent position for simulated environments. The knowledge so gained in no way compares to the knowledge gained in real experimental studies.

Remote Labs On-line

The use of a host computer that can be login to with terminal services so that you can be working with a real computer not with software simulation. Students are still dealing with real working computers and still have the freedom to make mistakes and do experimentation. The student's computer is simply used to make the connection to the host computer and doesn't take much resources of the student's computer. Once this is done, the remaining part of the project is

mmeybodi@aut.ac.ir

to design to make connection via the Internet. This setup can be very expensive for an institution to implement. One explored area would be to use Virtual PC [11] for the servers.



Virtual PC Windows Screen shot

This software allows run multiple PC-based operating systems simultaneously on one workstation or server, providing a safety net. If a student configures the server in such away as to lock it up or get it totally messed up, Virtual PC allows a way to reload the default ISO image so as to set the server back to start without having to reboot the workstation. Whereas Microsoft Virtual PC is a virtual machine solution for desktop operating systems. Microsoft Virtual Server [12], on the other hand, is a solution for server operating systems. Although Virtual PC and Virtual Server share many features in common, they are designed for different purposes. As a result, some of their features are also quite. A student can create a library of virtual machines in different server configurations without needing to dedicate a physical computer to each configuration. The student can then easily deploy their virtual machines from this library with a few mouse clicks. The student can also set up the virtual machines to use undo disks so that changes can be discarded, or they can use differencing disks to create a variety of configurations from one base disk. This is useful in situations where students can experiment with different configurations. The student might use this approach to test the effect of a configuration on the network. In addition, the student can quickly create virtual networks that simulate physical networks. Then the student can then test real-world scenarios on their virtual network. This also requires a large investment for an institution. This method also does not have any student management tools to manage and grade student's activities. The price is right. It is free for the Virtual PC and for the Virtual Server. I have student in my online class and my on campus class downloads Virtual PC and uses it on their home computers. The students can experience a great amount of experimentation with these products and still maintain the integrity of their systems. Windows Server 2008 is scheduled to have virtualization contained in the operating system when released.

As the working networking administrator over the computer labs at WT, I have moved the eight servers we have to a virtualized environment. I use VMWare running on Dell server. The response time, the savings in hardware upkeep, maintenance, and support have been great.

LabMentors [13] provides guided on-line labs for web-based training. They provide real-time mentoring in a lab environment over the internet. It can be integrated with your courseware with partnerships like for Thomson Publishing. Students can log on anywhere, anytime to gain hands-on experience and advice in the study of Linux, Windows, Cisco, or Novell training programs/certification tracks. Students will receive a block of time for use on the remote virtual servers. This method cost can be tied to teaching materials and doesn't require an institution to invest in expensive infrastructure to deliver the same material. Add the student management tools to LabMentors solution and you have a very good way of delivering labs remotely.

Conclusion

Distance education for courses where there are no experiments involved like mathematics or history might do a justice to the needs of the student at a distance. However the scenario is entirely different when hands-on experiences form an integral part of the course content. While simulation packages have a role to play in distance education there is a need for some real and practical laboratory knowledge. The measure of proof will be when the cost reduction in implementation and upkeep of computer labs has been reduced. The success of student skills will show success in the implementation of virtual computer labs. Hence, this innovative concept of having a virtual lab online could only be the beginning to a new era in the history of on-line education. I find a mixture simulation and virtualization a good mix until the

mmeybodi@aut.ac.ir

technology becomes more mature. Virtualization is becoming a great tool to teach and has many ways it can be used in experimentation.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Ultrasound Medical Diagnostics Laboratory for Remote Learning in EVICAB* Campus

R. Jurkonis, V. Marozas, A. Lukoševičius
Institute of Biomedical Engineering, Kaunas University of Technology
Studentų str. 65 - 107
LT- 51369 Kaunas, Lithuania

Abstract- **The aim of this paper is to present the development of remote learning laboratory for ultrasound medical diagnostics. We demonstrate the implementation of such laboratory using virtual instrument that is built by using standard PC, ultrasonic transducer with tissue like phantom, digitizer (Picoscope ADC 212/100, Picotech Ltd.), function generator (Hameg HM8131-2, Hameg Instruments GmbH) and popular software package LabView (National Instruments Inc.). By controlling the virtual instrument it is possible to excite and receive ultrasound waves in pulse echo mode then process the received echographic signal and get the characteristics of tissue like phantom. The tissue like phantom is characterized with thickness and density also with the speed of waves propagation and attenuation coefficient. The students are motivated by the assignment of the clear task - to identify the material from which the phantom is made. The implemented virtual instrument is based on NI Remote panel technology. This technology allows to access the virtual instrument remotely using internet browse. The lab preparation materials: goal, theory, quizzes are available from e-learning platform Moodle. We expect the students will improve their knowledge of ultrasound tissue characterization using our remote hands-on labwork.**

Keywords: ultrasound, medical diagnostics, remote learning laboratory, courseware

I. Introduction

John Dewey (1859-1952) was an American philosopher and educator whose writings and teachings have had profound influences on education in the United States and around the world [1]. Dewey's philosophy of education called pragmatism and teaching methods focused on learning-by-doing (experiential learning) rather than rote learning and dogmatic instruction, which were common practices in his days. For Dewey, it was vitally important that education should not be the teaching of mere dead fact, but that the skills and knowledge which students learned be integrated fully into their lives as persons, citizens and human beings.

Internet helps to make feasible the Dewey's ideas as new kind of laboratories- remote laboratories appear with real interactive experiments by using internet connected laboratory equipment: measurement instruments and devices under investigation. Emerging technologies of electronic learning and teaching platforms are spreading in the higher education system. Many examples of remote labs for different subjects do exist already: in electronics [2] and microelectronics [3], systems and control [4] and photonics [5].

However, the implementation of remote lab for such specific subject as Ultrasound medical diagnostics is not widely published yet [6, 7, 8]. We can refer to grant awarded implementation by H. Ewald et.al [9] who published their experience in remote ultrasound experiments. The specifics of ultrasound technology and the importance of knowledge in ultrasound diagnostics motivated us to create the advanced courseware for graduates in Biomedical Engineering program. In this paper, we present the development and implementation success of Ultrasound medical diagnostics laboratory for remote learning.

II. Motivation and Methodology

The common established clinical practice of medical diagnostics, sonography, aims to non invasively characterize structure of internal human organs. We can illustrate usage of ultrasound diagnostic systems with a number of these diagnostics cases at university hospital in Lithuania: near 91 thousand procedures per 2004 year [10]. These volumes argue themselves how it is important to maintain the adequate competence of medicine doctors and biomedical engineers in principles of ultrasound medical diagnostics.

The most frequent form of sonographic systems is images of internal anatomical structure i.e. qualitative data. Evaluation or interpretation of those images is the specific and complicated expertise field of radiology-sonography professionals. The image processing software tools are applied to interpretation of sonography images often without waves and tissue interaction taken into account. However, the survey of research publications shows the increasing specialization of sonographic systems for diagnostics of particular organs and increasing demand for quantitative data about the tissues under investigation. Description of biological tissue non-invasively in quantitative parameters is called tissue characterization. We can provide a whole row of modern attempts of ultrasonic

* EVICAB (European Virtual Campus for Biomedical Engineering) project is funded by the European Commission under the program Education and Training; http://www.evicab.eu/.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 453–456.
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mmeybodi@aut.ac.ir

tissue characterization in scientific research papers: diagnostics of body common tumors [11]; diagnostics of breast tumors [12]; characterization of myocardium [13]; evaluation of vascular condition [14]; evaluation of elasticity of eye lens [15], determination of liver suitability for transplantation [16], characterization of bones [17] and cartilage [18], tissue attenuation imaging [19]; or parametric imaging with sonographic system [20].

Responding to such demand we are aiming to teach the students the principal side of sonographic technology in-vitro, which is building component of the pulse echographic method to characterize the biological tissue. In-vitro experiments gave the basic data about ultrasound wave propagation parameters, such as: sound speed, sound reflection from and transmission trough tissue boundary interfaces, sound waves attenuation.

A. Learning content of laboratory experiment.

The main goals of experiments are:

1. Demonstration of ultrasound wave's phenomenon and to structure possibilities of theoretical calculation and hands-on experiments.

2. To perform experiments with ultrasound waves, to learn waves application possibilities in ultrasound diagnostics.

3. Provide knowledge in operating computerized experiments, when pulse echo waves are applied.

Laboratory experiment includes four main stages: self-sustained preparation and preliminary tests before experiments; hands-on experiment, results documentation and report preparation, interpretation of results, conclusions and after labs testing quizzes.

1. Preparatory stage. Students should study laboratory description texts before starting the experimenting. Then he/she calculates relevant parameters, familiarizes with experiment hardware and software. During preparatory calculations student starts drafting the report, quality of which is improved in the following stages.

2. Practical stage. Students accomplish hands-on experiments using remote panel of the virtual instrument according to description in Moodle courseware. The obtained results are saved in the graphical and numerical format into draft of the report.

3. Documentation stage. Students taking the course are advised to use electronic form of experiment report to make the preparation more easy and purposeful. We think that such electronic preparation of the report preserves students' energy and time and facilitate students for analyzing, thinking about and perceiving the findings of the experiments. The report draft form, as a guide trough experiments, is available for downloading. The students begin to fill in the form during self-sustained preparation for experiments. During experiments students are collecting (inserting) graphical and numerical results of the experiments into the report. After completing experiments students process the results and further improve the quality of the reports. Finally, students formulate conclusions taking into account experimental and calculated results and, by comparing the experimental results with calculated ones, they have to answer labs quiz.

4. Formative assessment stage. Students should take the after-lab quiz, which is prepared in order to test how well the students have perceived the findings of experiments and have learned the subject. The after lab quiz is available online in Moodle learning platform.

III. Software and Hardware

A. Courseware platform - Moodle

We describe here so-called courseware or the didactic materials for self-preparing and performing the remote laboratory experiments including texts, equations, test quizzes, the software and hardware installed on remote laboratory. The materials contain the methodology description and derivation of equation how to characterize material from features of echo pulses. The equation contains echogram and pulses data given in Fig.3 b. The calculations of parameters are programmed in the virtual instrument, but students after reading the method development chapter should get an idea of these "hidden" calculations. Experimentally estimated parameters help students to identify what the material was in the phantom. Identification of material is the interpretation task for students. They should compare obtained parameters with the parameters from the materials catalog and identify investigated material.

The learning materials are available in EVICAB project's e-Learning platform Moodle. This web site serves students and is good alternative of textbook. Implemented quizzes facilitates assess of knowledge improvement after experiments.

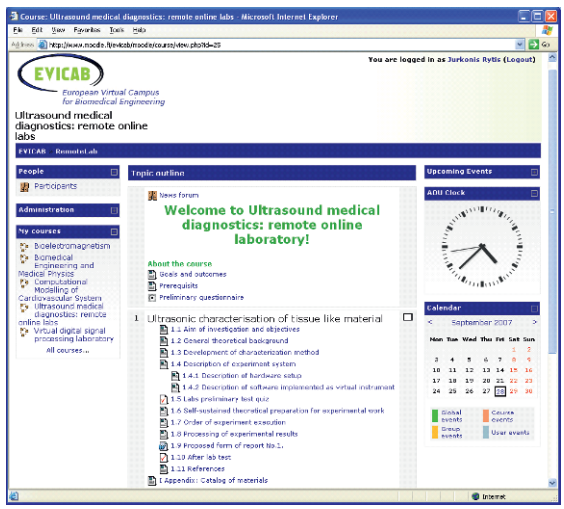


Figure 1. The screenshoot of Ultrasound Medical Diagnostics e-Learning platform implemented in Moodle. It is possible to visit using this link: http://www.moodle.fi/evicab/moodle after registration.

B. Virtual instrument software

Virtual instrument is a program that implements functions of the measurement instrument with the aid of computer and some peripherals: signal digitizer, generator etc. Virtual

mmeybodi@aut.ac.ir

instrumentation concept was introduced by National Instruments Inc. (NI) 20 years ago. NI's software package LabView is widely used for development of the software for virtual instruments [21]. We have also used LabView for development of virtual instruments for on site lab work at laboratory [22]. Digital signal processing is performed using software tools in virtual instrument. The raw echogram was prefiltered with bandbass filter to sub-press noise. Amplitude data in echogram is evaluated automatically by virtual instrument, but the delay data of pulses is evaluated by manual scrolling of virtual control. The virtual instrument calculates the following parameters of tissue like material: thickness *d*, density ρ, and ultrasound waves speed *c*. The fast Fourier transform computed the amplitude spectra of echo pulses, then log spectra differences were approximated linearly using least square method. From slope of approximating line the attenuation coefficient β is estimated. Methodology of material characterization is so called substitution method and is adopted from [23].

The developed remote panel of virtual instrument is also able to set-up hardware remotely, to process the acquired data and to present the numerical and graphical results on the remote panel over internet connection (see Fig.2.).

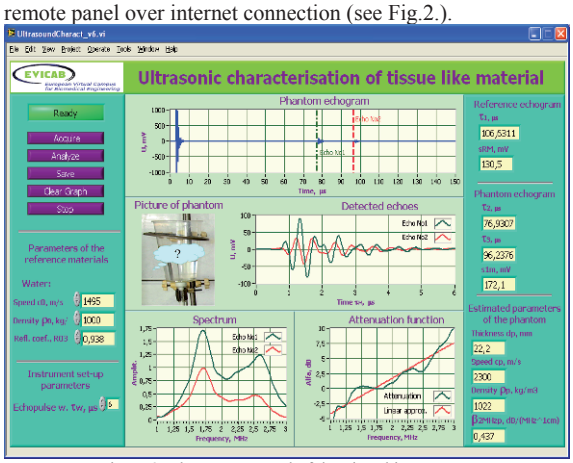


Figure 2. The remote panel of the virtual instrument.

We faced the problem when shifting from on site labs to remote labs: how to organize experiments so that all students could have opportunity to perform experiments remotely without disturbing each other. The partial solution to this problem could be the time scheduling or booking system [24]. The phantom samples could be interchanged by the teacher according to known schedule.

C. Hardware

The experimental system is based on high speed (100MHz), high resolution (12bits) digitizer Picoscope ADC 212/100 (Pico Technology Ltd., Cambridgeshire, UK), function generator Hameg HM8131-2 (Hameg Instruments GmbH, Mainhausen, Germany), ultrasound transducer (central frequency 2,25 MHz, aperture 13 mm in diameter), matching circuit, and custom-built software in LabView (Fig. 3 a). The digitizer is used for sampling and acquisition of ultrasound signals. Digitizer and computer are connected via LPT (parallel) port. The function generator is used for excitation of the transducer and for sending the pulses of ultrasound waves into phantom. Ultrasound transducer is excited with pulse, which duration is controlled from virtual instrument via IEEE-488 (GPIB) interface.

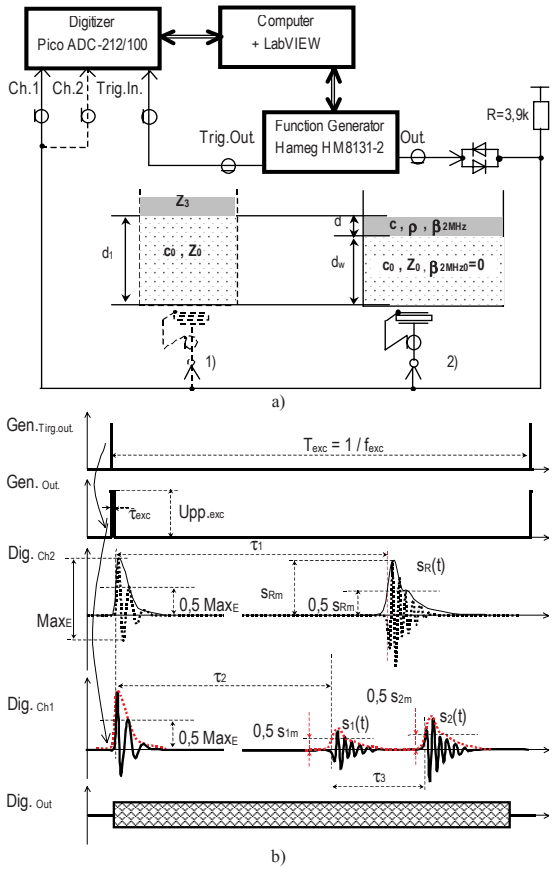


Figure 3. The structure of experimental system (a) and time diagrams illustrating the tissue characterization method (b).

IV. Discussion

We would like to discuss our experience in implementing virtual experiments system for remote learning of ultrasound medical diagnostics principles in a few aspects. The first aspect we want to discuss is the amount of interactivity needed to perform the experiment. There is danger of too much automatic experiment when students will lack the interaction. On the other hand, if students are left with manual processing of the acquired data, the path to the results could be too complicated for them and nobody will succeed. Thus the goals, to show the power of ultrasonic tissue characterization, could be not reached. The practical clinical applications of experience gained in the experiments could be tissue characterization at

mmeybodi@aut.ac.ir

tissue banks for transplantation, or at pathology and anatomy departments where characterization results are verified. The third aspect of implementation is collaborative work of experts from different fields. The co-authors have put together their specific knowledge during implementation of labs platform. One co-author was ideological leader of labs methodology, the other was expert in ultrasound. In this way, we found feasible the adoption of newest methods and solutions of ultrasound diagnostics [25] for learning. The third important contribution was the knowledge of LabVIEW virtual instruments and of learning platform Moodle.

Analog and digital electronics equipment, ultrasound transducers and digital signal processing software tools from LabVIEW are used in remote labs. The hardware is as standard as possible, while the required specific signal processing methods are implemented in software tools and adopted for labs goals and objectives. Such composition of experiments equipment cut the price and eliminated depreciation of specialized and expensive hardware.

The digital domain signal processing algorithms are rapidly developing and have the increasing importance in ultrasound diagnostics. Virtual implementation of instruments will enable us easily to modernize the lab by the simple change of software algorithms. Therefore students will get the most up-to-date system to work with. This is important aspect of virtual experiments systems development taking into account constrains of capital and time resources.

V. Conclusions

We presented the approach of the remotely controlled laboratory experiments for the course of Ultrasound medical diagnostics in Biomedical Engineering master program. An approach was implemented and tested in one example of lab work "Ultrasound characterization of tissue like material". It should be noted that implementation of specific subject (e.g. Ultrasound medical diagnostics) on remotely controlled laboratory system is demanding work of collaborating experts. We think that such courseware implementations should be most efficient if at least one expert of ultrasound diagnostics and one expert of e-Learning platforms (e.g. Moodle and LabVIEW) would collaborate. We found it is feasible to implement a few more remote experiments using the same equipment for: sonographic M scanning and Doppler device principles learning in the future.

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mmeybodi@aut.ac.ir

An Integrated Course on Wavelet-Based Image Compression - Learning Abstract Information Theory on Visual Data

Sven Grottke, Sabina Jeschke and Thomas Richter
University of Stuttgart
Institute of Information Technology Services - IITS
Center of Information Technologies - RUS

Abstract- **We describe the implementation of and our experiences with a capstone course on wavelet based image compression held at the Berlin University of Technology in the years 2002 to 2006. This course has been designed as an "integrated project", which means that it combines lectures, seminar talks to be prepared and held by the students, and a programming part. The design goal of this course has been to provide all the necessary theoretical knowledge to understand the concepts behind image compression technologies, such as JPEG2000. We are also aiming at simulating the work-flow as found within an IT company as realistically as possible, preparing electrical engineers and computer scientists as well as possible for their professional life. This training does not only include the technical, but also the social skills required to successfully complete larger projects. The subject of image compression offers the advantage of requiring a solid knowledge on terms of information science such as entropy, distortion, quantization, Fourier and wavelet-transformation, but also offering a direct visual feedback of how these techniques perform. Therefore, we believe that image compression is an attractive topic to be used for a capstone course. Traditionally, a course would assign weekly programming exercises to the students; however, we believe this to be unsuitable for a capstone course as it does not simulate the work-flow of a professional software development team; furthermore, it does not require the degree of team-work we deem critical to modern software development. Thus, we divide students into groups of two to four people and assign each team to one sub-task of an image codec and provide some boiler-plate code of our own. Much to their astonishment, students soon find themselves spending a considerable amount of time with project management and coordination activities. That means, teams have to design interfaces and data structures to combine their efforts to create a working project, which adds an often underestimated social component to the course. With some guidance from the teachers, students have always been able to supply a working code at the end of the semester. Needless to say, the thrill of having a nontrivial working program at the end of the course is a major source of motivation for our students and adds much to the satisfaction and positive feedback we receive.**

I. Background

The field of image compression often attracts students of various fields: the technology is well-recognized in today's world, let it be as images found on the Internet, or as the compression engine in digital cameras. Students of technical fields are aware of the technology, and equipped with their basic knowledge of information technology, soon become curious about how these things work. Furthermore, compressing images also means looking at images – it is visual technology with a mathematical background.

Of course, things were not much different for the authors of this paper, even though we came from almost completely unrelated fields: Mathematical physics and computer science. In 2000, the IT bubble gave us a chance to explore our knowledge in a tiny startup company whose name is likely unknown to anyone else, and the breakdown of the bubble to learn the not so bright sides of it. We thus moved back from industry to university, hoping to pass some of our experience to students.

Our first try, a regular lecture on JPEG2000 [2] – about the only product our company ever sold – was not really a success. It followed the conventional teaching tradition, similar to most other courses held at German universities. The matter is complex, and students often find that understanding the subject requires more mathematics than they would like, and presenting something as visual as image compression on a blackboard, and maybe some images here and there, did not really help to improve matters. Hence, the course had to be redesigned completely and had to deviate from the regular teaching style.

II. The Design of a New Course

We started with what we expect our students to learn: Of course they should know how JPEG [1] and its related standards work. But we believe that just knowing and managing the technology is not sufficient to prepare them for their further careers. One of the skills one needs in industry is the ability to plan and manage large projects. And the team has to be organized as well: Students have to learn how to cooperate with their colleagues, an often surprisingly complex task in a large team, and a skill usually not taught at university level. Last but not least, as we were working at the Institute of Mathematics of the TU Berlin, we also considered it important to make our students understand the scientific foundations of the field.

Our idea was to simulate the work-flow of industrial software development as close as a university course would permit. The goal of the course is to provide a fully working image compression program to a "virtual customer" at the end of the semester – that is what we tell our students – and

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 457–461.
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mmeybodi@aut.ac.ir

learn all the skills required for this as the progress; the latter often means more than our students would initially believe. For that, after an initial introductory lecture, we break our audience into groups of two to four students and let them pick one of the sub-projects. Each sub-project corresponds to a key component of a realistic image codec. This means that each student group gets a different assignment; this is realistic, but not without problems, as we will show in section IV.

To prepare students for their task and to provide the required foundations, we make them give a one hour presentation to the whole class. In their presentation, they explain the technological backgrounds of their assignment, as well as their basic work plan for the rest of the term. The necessary materials, mostly technical and scientific articles, are provided by us during the initial lecture. This approach might seem a bit harsh, but it is part of our philosophy: it is just realistic that a professional IT engineer has to implement a project from the papers, and must learn the background by himself. Needless to say, we offer all the help to the students we can; in addition to keeping our offices open for them whenever they need assistance, students are required to talk to the organizer of the course at least one week in advance to their talk to get it straight, clear up the misconceptions and fix any errors. Thus, we do have some quality control for their talks.

Despite some boilerplate code provided by the organizers, the students not only implement, but also design their code themselves. As we find year after year, especially the latter causes major headache for our students. Apparently, up to this course, students never spend much thought in how to write a larger software project. It is also hard to make them communicate with each other, and not with the administrator to get the interfaces of their software modules straightened out. For more experiences on this, see also section IV.

At the end of the term – six months at our universities – the image codec written by the students has to pass a formal acceptance test, similar to what is required for professional projects. We keep testing the progress of the project within the semester and provide feedback and help, such that up to now every class had a working and acceptable "product" at the end of the semester.

III. Organization of the Course

We initially designed the course [10] around five modules, as found in a wavelet based image codec: Color transformation, wavelet transformation, quantization, rate allocation and entropy encoding.

To give a brief overview: the color transformation computes luminance and color coordinates from the red, green and blue intensities of the image, very much like what happens in color TV. This step provides a first decorrelation of the color planes of the image. The following wavelet transformer [6,7,8] (DWT in Fig. 1) decorrelates the original image by transforming it from the spatial into a frequency/scale domain, very much like the Discrete Cosine Transform in JPEG-1 does1. It is by itself not lossy, except for numerical round-off errors. Data reduction and thus compression is the task of the following quantization step, which is controlled by the rate-allocator. The purpose of the latter is to provide quantization parameters such that the image quality becomes maximal for the user provided output file size. Context modeling detects edges and corners in the image and provides the following step, the entropy coder, with a classification of the quantized coefficients. The entropy coder finally removes redundancy in the data by classical algorithms like Huffman coding [4] or arithmetic coding [5]; see Fig. 1.

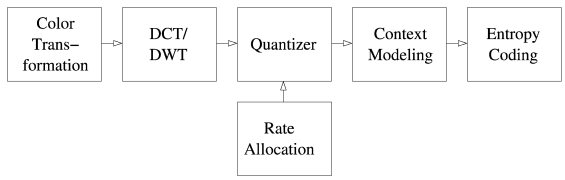


Figure 1: Layout of an image compressor, arrows indicate the data flow (see text above for details)

We also provide a fifth backup project that uses an alternative rate allocation scheme, the so-called zero-tree coder by Shapiro et al [3]. We later dropped the quantization module in favor of a context modeling module for reasons discussed in section IV and provide the quantization software and talk ourselves.

Some boilerplate code, namely to read and write images in the uncompressed PNM file format and service classes, including the color transformer and the quantizer, are also provided by the organizers, along with the architecture that builds the code. We picked C++ as the language of our choice as it has some relevance to the market, especially in still image and video compression. Even though Java gains a lot of popularity, it is rarely picked for computationally intensive tasks in the industry. The operating system of our choice is GNU/Linux, as provided by the computer lab of our department.

Participating students are expected hold a bachelor's degree[1] in electrical engineering or applied computer sciences. Even though not required, open projects similar to ours are often considered a direct preparation to the final diploma thesis and are thus taken by students in their last year as a "capstone" course. Thus, it is not too unusual that students pick up topics from our course for their master thesis.

The course itself [10] is scheduled to take up four hours per week, two hours spend in a lecture hall, and two hours in the computer lab where students have to show up to work on their code. Even though students could in principle write their software at home, we require them to meet in the lab to be available for their colleagues for discussion and help. Of course, the lab remains available to students outside theses hours as well.

[1] Actually, „Vordiplom" in Germany, which is roughly equivalent to a bachelor, but not a separate study. The German system is currently undergoing a change to the bachelor/master system.

mmeybodi@aut.ac.ir

The schedule of the course is rather delicate: Some modules depend on the result of others and have to be finished early, while others may delay their work to the mid of the semester. For example, pretty much everybody requires the output of the wavelet transformation step, but the rate allocation could be completely omitted, at least in theory. To address these dependencies, we fix the dates for the student talks in advance and set deadlines for the projects. Some students have to volunteer for earlier projects, e.g. the wavelet group has to complete early, while others need to complete their module rather quickly at the end of the semester, e.g. the rate allocator group.

To allow the early groups to read into their topic and get their talk prepared, the first three lectures on color spaces and color transformation, on the project architecture, and on the revision control system that maintains the project sources, are given by us. The middle part of the semester, usually up to the Christmas break, is spent with student talks. During the remaining term, we discuss extensions and refinements of the technology, while students are busy implementing their modules. Subjects such as the JPEG 2000 EBCOT rate allocator [2], which we do not require to be programmed by students due to its complexity, and mathematical properties of wavelets are discussed during this time. Since all the foundations are now available, we are also able to provide a deeper insight into the mathematical backgrounds: DWT and DCT are an ideal motivation to discuss function spaces and Fourier transformation, whereas context modeling and entropy coding are applications of probability theory and random Markov fields. Depending on available time and request, alternative compression schemes, e.g. JPEG-LS [9] or PNG are also discussed here. The final week is spent on preparation for the acceptance test and we often found it necessary to extend the course by one week for additional bug fixing.

Passing the course requires assessment of three independent activities: First, we review the talk a student group gave in class. Is the talk correct? How deep does it delve into the topic? Was the presentation sound?

Second, we assess the code delivered by them at the end of the semester: Does the code work and deliver proper results? Is the code carefully designed, and are we able to follow the program-flow? Is the programming style consistent and appropriate? Our focus is less at execution speed and compression performance but on technical soundness.

Finally, as so far we only have been able to assess the group as a whole, we require a final oral exam to be taken individually after the course. We require students first to give an overview on the topic of the course, explaining the purpose of each module and a rough description of its function, but then focus on the particular topic of the group the student was participating. In this part, we ask both questions on the theoretical foundation of the corresponding module, as on the concrete implementation to test the students understanding on the actual program his group delivered.

The final grade is then a weighted average of the grades of the talk, the quality of their software and the grade of the final exam. We initially allowed the oral exams to be taken in groups, but switched over to individual exams for reasons discussed in the next section.

IV. Lessons Learned

One very general problem of the course is to setup the available projects such that their difficulty level is comparable. Specifically, in the very first course we observed that weaker students were attracted to the quantization project, because it is simple as far as the implementation is concerned, even though the mathematics are quite complex. However, the latter is often not realized by students, and causes unpleasant surprises when the talk has to be prepared. We thus decided to make the quantization talk a regular topic of the lecture and provided a replacement project on context modeling in the next and all following years. To our surprise, it is much less popular than our backup project, the Shapiro-Zero-Tree coder, even though the latter requires even higher skills in software engineering. As a result, even weaker students are now regularly attracted by the more complex issues such as rate allocation and, to our satisfaction, they always managed to complete them successfully.

Teamwork and project management often cause more trouble than students initially expect. In particular, students frequently approach us, the organizers, with questions about the code or the interface definition of other teams. It is part of the learning process – ours as well as that of the students – to directly refer them to the corresponding team and to meet in a larger group if issues have to be worked out that require an even broader audience. We do not feel that the need of holding meetings is a bad thing – it will certainly become an important part of their professional life.

Related to this issue, software design -as opposed to just implementing code- also seems to be very unattractive to students. It is clearly much more convenient to accept a design as given and hack in the code than rather to think of the project as a whole, but we also need our class to understand the big picture. Designing the code is now done in one regular lecture and several meetings over the course of the semester, where the organizers act as “consultants” explaining the benefits and drawbacks of the ideas our students come up with. It happened once that one dominant student proposed a – in our view unattractive – design idea how to organize the wavelet bands, but we decided to let the group go. It turned out later on, unsurprisingly, that the proposed solution caused quite some headache. Nevertheless the course was completed successfully in time and no damage was done to the project, but students surely learned the importance of design decisions, and hopefully that the loudest persons are not always the wisest. Clearly, not intervening is always a risk to the course, but providing a working design in first place contradicts the learning goal. We thus restricted our role to moderating the design meetings and not making any final decisions. Needless to say, this often seems to surprise students.

mmeybodi@aut.ac.ir

We initially allowed students to take the oral exam in groups of three, but soon found this unsuitable to provide grades to individual students because there is often a single dominant student in the project who will answer most of the questions, making it hard to address the quieter members. Exams are now required to be taken individually.

It proved very helpful, though, to meet the students in advance to their presentations to discuss the talk they were about to give. This often clears out misconceptions, and gets the talk on focus of what we think is important to learn and what is important for the mathematics that follows later in the semester. In addition, we ask the class to collect questions to the presenters while the presentation is running and add a couple of questions of our own. Initially, our classes considered our questions more of an inconvenience for the presenters. We now make it very clear to them that these questions are meant as a way of assisting them with their preparations for the exams, as they are a tool to point out what we consider relevant in the course.

In addition, we also give away the secret of the first question given to all participants: "Please draw a block diagram of an image codec", i.e. reproduce Fig. 1, and explain the purpose of the boxes. It does not really take much time, and breaks the ice by allowing the examinee to get more comfortable in a stressful situation.

Concerning the organization of the course, the proper timing has been found very critical, as already mentioned in section III. Students often underestimate the time to get the code running correctly, and only start working on the computers when it is already too late – unfortunately, this matches our own experience in the industry only too good. We will address this point in the next year by providing them with two software projects to be solved: One small introductory assignment that requires students to get familiar with their topic and the software architecture of the framework, and the actual code for the image compression codec. The former does not require interaction between the teams and thus does not cause any additional time constraints in the setup of the course, and we can still cancel it if it takes too much time.

The first project should ideally provide some useful data for the final, second code: For example, as an add-on project for the entropy coder module, we plan the assignment to write a program to measure the image statistics and compute the zero order entropy from that. We expect this to help students to get familiar with both the theoretical background required for their talk, and with the development environment by forcing them to work on the computer. We have yet to see how this idea will work out.

One of the ideas our students themselves came up with is to make them hand in a routing card for the exam; this forces students to come into the lab frequently, at least to get the card signed for every appointment we make, and thus requires them to work more regularly on the program.

V. Evaluation

The German university system does not require evaluation of courses, but we nevertheless asked our classes to fill out evaluation sheets provided by the student union to all lecturers on a voluntary basis. This evaluation sheet grades lectures on a range from 1 to 6, following the German school system, where 1 is the best and 6 the worst possible degree, very much unlike the US system. The evaluation sheets are collected anonymously at the end of the semester. In addition, we keep asking our students for comments and suggestions after the completion of the exam. At this point, the grade is already set and students can talk to the organizers more openly.

Our course consistently collects grades between 1.2 and 1.5 on average and makes this one of the highest graded courses of the institute of mathematics. We collected a lot of positive feedback, but a couple of critical comments as well. To quote one of the students: "This was the first reasonable course I ever took" - it seems something must be wrong with the undergraduate courses in electrical engineering. It is often well appreciated that our course combines the solution of a practical problem, and thus a hands-on approach to the problem, while it also provides the theoretical background material. Thus, students seem to like learning how things like JPEG work by actually creating a working implementation of their own.

From the critical voices we collected, the two issues coming up most are that the high amount of mathematics in the course is disliked, and that the software design meetings have been found to be annoying. The first point is not negotiable – image compression is applied mathematics, and we don't believe that cutting the mathematics part down will improve the understanding. We try our best to make the mathematics visible – also in a very literal meaning – and found that this works much better than by just working on the blackboard.

Concerning software design, compromises have to be made. On the one hand, it is clearly easier for the students just to follow a fixed course set by the lecture. On the other, if engineers do not learn how to design software while they are in university, they have to in their jobs – which might cause them some serious trouble. We try to address this issue by acting as senior engineers in the design meetings.

Our experience with students is that we found the overwhelming majority of them very engaged and actively contributing to the project. A minority, often two or three individuals, take the course because they don't seem to have found anything more fitting. This relation is also mirrored in the final grades students collect. Unlike a Gauss-shaped plot one might expect, we are often proud to provide many very good grades, but also a couple of bad ones. Passing the course with a mediocre ranking seems to be hard – if you're interested in the technology, the course seems to be exactly what you need and it can pretty tough otherwise.

VI. Future Work

One of the problems we definitely need to address is to make our students aware of the critical timing of the project, and that developing working software costs more time than one believes. We have yet to see how well our approach of assigning initial mini-projects to students work in this

mmeybodi@aut.ac.ir

respect. A second challenge is to keep students convinced that software design is a serious issue. There does not seem to be a perfect solution to this problem, but anything we can do in practical programming projects seems to address this much better than a theoretical lecture on the topic.

ACKNOWLEDGEMENT

The authors want to thank Prof. Sikora and the Institute for Nachrichtenübertragung for the kind cooperation and making this project possible. We further want to thank the Institute for Mathematics of the TU Berlin for financing and support and Pegasus Imaging for sponsoring.

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mmeybodi@aut.ac.ir

MOSFET Amplifier Using Advanced Analysis in PSpice

Saeid Moslehpour[#1], Gurbir Tur[#2] Chandrasekhar Puliroju, [#3]
[#1,#2,#3]Department of Electrical and Computer Engineering, University of Hartford, West Hartford, CT, USA
[#1]moslehpou@hartford.edu
[#2]tur@hartford.edu
[#3]puliroju@hartford.edu

***Abstract*— This paper incorporates the use of Advanced Analysis [3] of PSpice for exposing the students to some involving procedures of circuit building. After reading through the various properties that have been displayed, it would seem as a compulsory learning and assessment tool for the students which not only helps them interact with the circuitry, but, become much more involved with the practical aspects of electrical systems.**

***Index Terms*— , Sensitivity analysis, smoke analysis, performance analysis, Mote Carlo Analysis.**

I. INTRODUCTION

The present project serves as an application of the knowledge gained from past studies of the PSpice program and implements some of the advanced analysis to the circuits. The study will show how PSpice can be used to analyze complex circuits being affected by various parameters like temperature, stress, durability of the component. In other words, the study will involve four types of analysis which help in testing some of the aspects even before the circuit is physically built. Sensitivity Analysis [1], Monte Carlo [2], Optimizer and Smoke Analysis are the analysis used to test the following aspects.

1. It helps check them for durability
2. It can optimize them by suggesting an optimum value for the various components
3. Surprisingly it even tells the probability of a certain range of outputs with the respective change in the value of components. This is done with the Monte Carlo Analysis specifically
4. Warning about the possibility of burn out of certain components.

Thus a large amount of time is saved by avoiding mistakes while doing the actual printed circuit boards saving a lot of time, effort and financial resources. This report is useful for students who would like to know more about the PSpice program and how it is useful for many educational purposes.

II. DESCRIPTION

The circuit diagram of the concerned circuit is given above in Fig.1. The term MOSFET is an acronym for *metal-oxide semiconductor field-effect transistor,* a common type of

Circuit Diagram

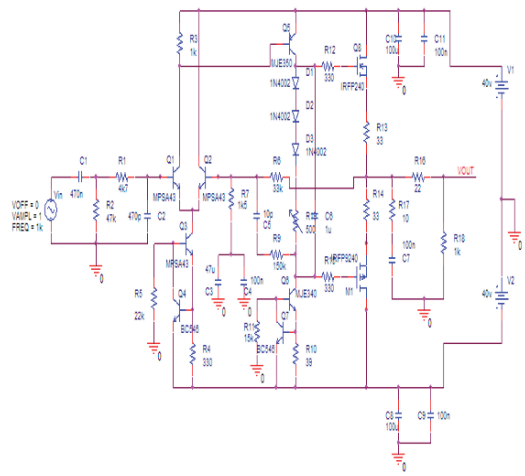


Fig. 1 Circuit diagram of MOSFET amplifier

transistor in which charge carriers, such as electrons, flow along channels. The width of the channel, which determines how well the device conducts, is controlled by an electrode called the gate, separated from channel by a thin layer of oxide insulation. The insulation keeps current from flowing between the gate and channel.

MOSFETs are useful for high-speed switching applications and also on integrated circuits in computers.

We used this transistor for the purpose of an audio amplification.

An input signal of 1 volt was given to the amplifier which produced an amplification of up to 22 volts without distortions. The amplified output of an audio signal is as shown in Fig. 2 on the following page

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 462–466.
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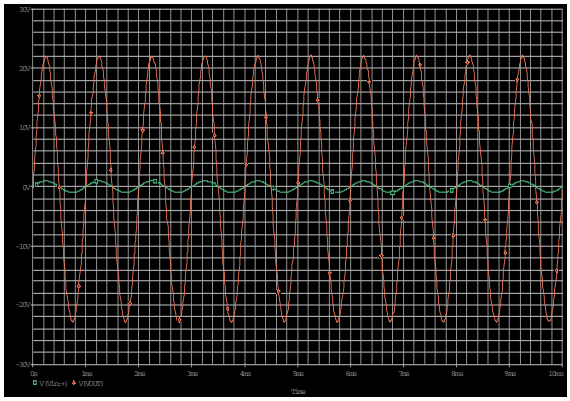


Fig. 2 Output waveform of MOSFET amplifier [4]

III. PROCEDURE

A. MONTE CARLO ANALYSIS

For PSpice Monte Carlo analysis, you can setup only one goal, which should be specified before the simulation, whereas in case of Advanced Analysis Monte Carlo analysis, you can set multiple goals. You can also add or modify these goals after the simulator run and multiple profiles can be included in a single analysis. Since the components used for building circuits never have the precise values in reality, thus the output of the circuit also varies (in the parameters chosen for consideration). Monte Carlo is an advanced statistical analysis, which predicts the performance of the given circuit on the desired parameters. By parameters we mean performance of the schematic, which in our case is chosen as the 3dB Lowpass cutoff of the output voltage and a couple of others.

The following sections will clarify the content mentioned above by simulating this statistical analysis on the chosen circuit. It has been divided into different stages for simplicity, and are given as following:

1) *Preparing the Circuit:* Make a new schematic in the existing project by right clicking on the project (MOSFET Amplifier in this case) name it Monte Carlo. Create a new page in this schematic and copy the original circuit (with all the advanced analysis parts). Another option is create a new project by selecting File>New>Project. Name it Monte Carlo Analysis. Verify that the Analog or Mixed A/D radio Button is selected. Make sure that you click the *"create based upon an existing project"* button. Navigate to the original circuit and click ok.

2) *Assigning Tolerances:* By tolerance it means the variation in positive or negative direction for the various components that are being given this. In Capture, select place >Part. Place a copy of the "Variables" symbol. It can be found in *special.olb*. Set the value of RTOL and CTOL to 10. (This is the weight given to resistive and capacitive tolerance) A Screen shot of the same is shown below. See Fig. 3.

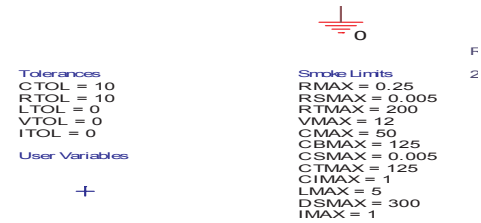


Fig. 3 The Variables symbol showing values of tolerances [4].

Edit Part properties of a resistor R1. Set POSTOL & NEGTOL to 20% each. (In some cases just the TOLERANCE property is given such as in the current one. Assign it a value of 20%.)

3) Simulating Profiles: Run the AC and DC profiles. The parameters that are going to be discussed further in the analysis are arrived upon by simulating the circuit in two different profiles. These are the AC and the DC. We used the starting frequency as 1Mega Hertz and the end frequency as 600 Mega Hertz. If needed the sweep of frequency can be shortened or expanded depending upon your requirements. The simulation setting windows for both of them are shown below in Fig.4. and Fig. 5.

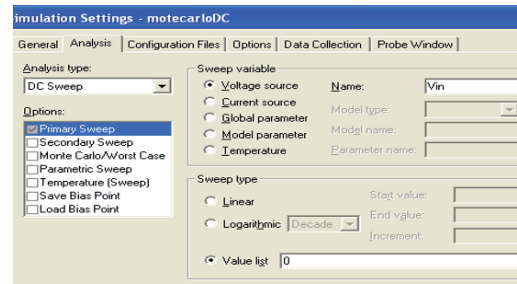


Fig. 4 Simulation settings DC profile [4]

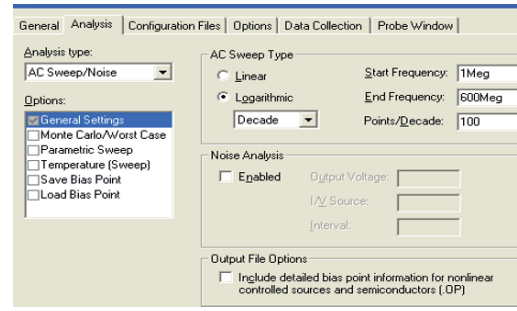


Fig. 5 Simulation settings AC profile

4) Self Check runs and measurements: This step includes selecting the measurements that Monte Carlo will use. In our case we used the Bandwidth (Cutoff_Lowpass_3dB(1)), Gain (V(out)), Power W(Q1) and Collector Current I(Q1:C).

5) Running Monte Carlo: On running Monte Carlo we get a CDF plot as shown below in Fig. 6.

mmeybodi@aut.ac.ir

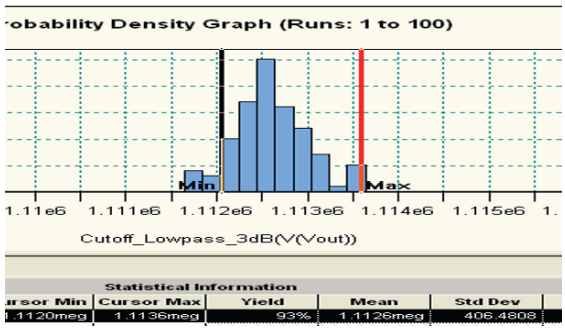


Fig. 6 PDF plot predicting possibility of the getting the bandwidth in the shown range.

Similarly the option of getting the Graph in CDF[2] domain in also available. See Fig 7. at Bottom

B. *OPTIMIZER ANALYSIS*

The optimizer analyzes analog circuits and systems, fine-tuning designs faster than trial-and-error bench testing. It helps find the best component values to meet performance goals and constraints. Designers can use the optimizer to improve design performance, update designs to meet new specifications, optimize behavioral models for top-down design and model generation, and tune a circuit to match known results in the form of measurements or curves. The optimizer analysis feature is used to find out optimal values of circuit components, for most efficient working of the circuit. These values would otherwise be derived after a lot of trial and error testing [3].

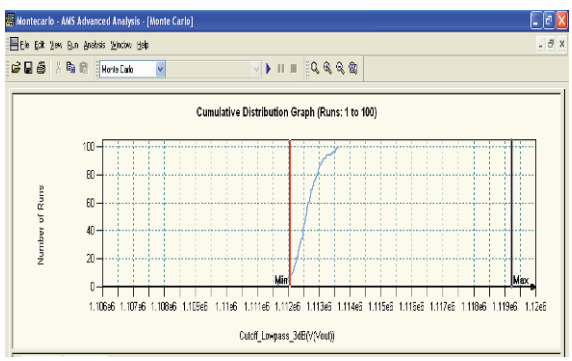


Fig. 7 Cumulative distribution graph for Monte Carlo

A somewhat similar approach as Monte Carlo is required. It goes as follows:

Preparing the Circuit: Replace value of a resisto R1 from 4k7 to RES. Then add the variables symbol to the design and double click on it. Add "New Row" or "New Column". Define this new Variable as "RES" with a value of "1.!e3"

1) *Simulating Profiles:* Run the AC and DC profiles. See Fig.8 and Fig. 9.

2) *Self Check runs and measurements:* Same as Monte Carlo.

3) *Running Optimizer:* Select Run>Start optimizer. The results generated can be seen in Fig. 10. on the next Page.

We find that all the components have been optimized and the optimized values are shown in the "Current" value Column. The minimum and maximum value range through which these components have been analyzed is also shown in the columns before it along with the simulation profile that is associated with the concerned component.

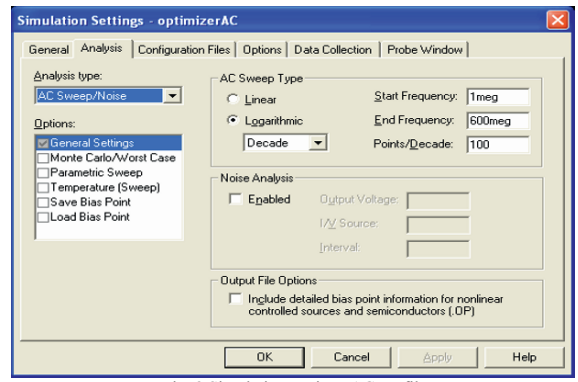


Fig. 8 Simulation settings AC profile

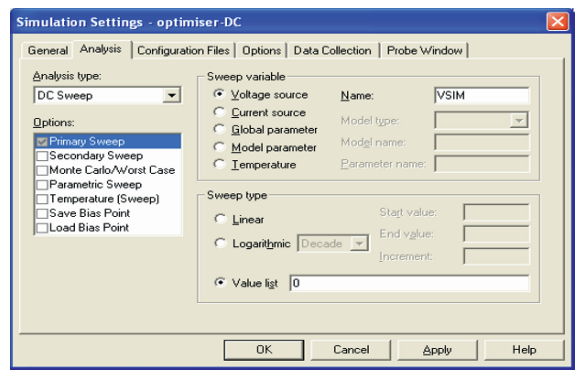


Fig. 9 Simulation settings DC profile

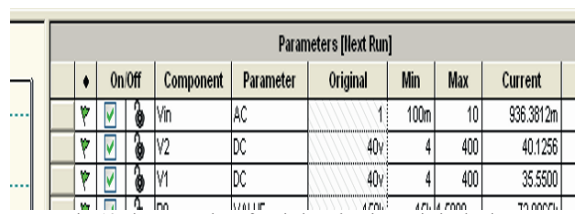


Fig. 10 The screen shot of a window showing optimized values

C. *SMOKE ANALYSIS*

Smoke analysis is essentially a stress analysis which warns of stressed components due to power dissipation, increases in junction temperature, secondary breakdowns, or violations of voltage/current limits. Over time, these components can cause

mmeybodi@aut.ac.ir

circuit failure. This analysis calculates the Safe Operating Limits for the schematic. The Safe Operating Limits are calculated based on the maximum operating conditions (MOC) and Derating factors from every component and device in the design. For example default values for max Power and Temperature in a resistor are given by RMAX and RTMAX respectively. Similarly there are numerous maximum operating conditions for all the components and have suggestive names such as CMAX for capacitor and LMAX for inductor. After performing somewhat similar adjustments we run the analysis and find out the weak components [4]. See Fig. 12.

Max Out refers to the burnout of a component due to operating outside its prescribed limits. From this chart we can easily see which components Max Out and thus need to be replaced by a more robust version.

After replacement, we again run the analysis to verify the results .These results include fewer components that are "Maxing" Out. Thus, this analysis is very helpful in finding out

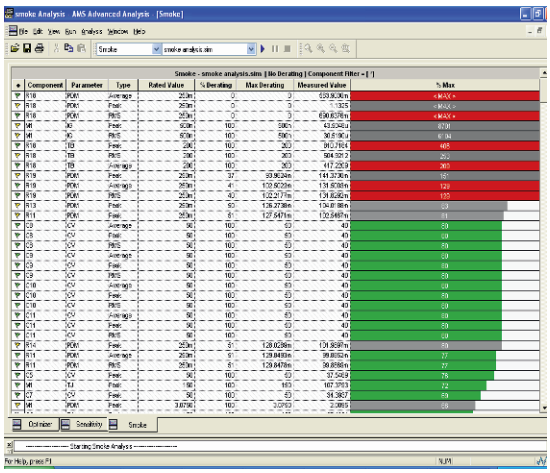


Fig. 11 Results for Smoke Analysis

values safe for testing, without even testing the circuit once.

D. SENSITIVITY ANALYSIS:

The sensitivity analysis identifies which component parameters are critical to the goals of a circuit's performance by examining how each component affects circuit behavior by itself and in comparison to the other components. It allows us to identify sensitive components and export them to the optimizer to fine-tune circuit behavior. It can be relative or absolute sensitivity as well. Sensitivity analysis can be run with an AC sweep, DC sweep or Transient analysis. Sensitivity analysis performs three types of runs:

- Nominal run: Every parameter is set to its nominal value.
- Sensitivity run: One sensitivity run occurs each time a parameter value with a defined value of tolerance is raised to 40% of its positive tolerance limit while others are kept to their nominal values.
- Minimum/Maximum runs: Worst-case values are calculated for the output by moving all parameters to the ends of their tolerance ranges in the direction that reduces them to a minimum and increases them to a maximum.

Define all the individual tolerances for the parts that have to be analyzed. Discrete values specified for the tolerances will override global tolerance settings for the device. Before running sensitivity analysis we have to run the basic PSpice simulations to verify that the circuit is behaving as expected and that our functions are correct.

In PSpice, create a DC and AC profiles. See Fig. 12.

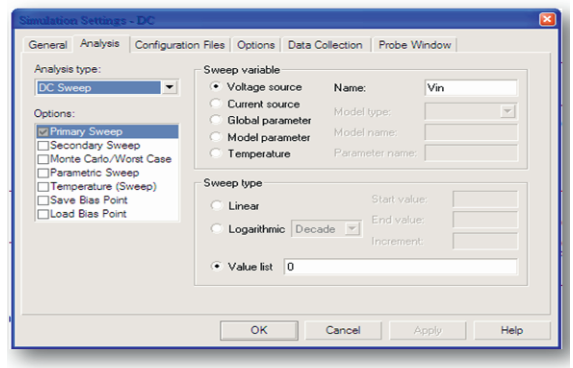


Fig. 12 Simulation settings DC profile

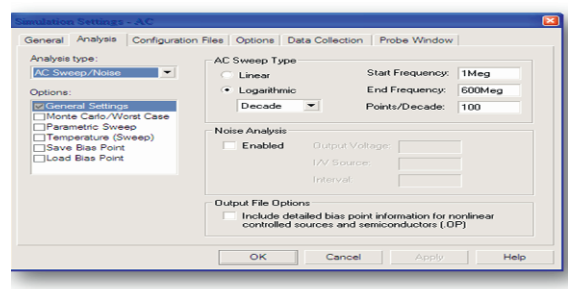


Fig. 13 Simulation settings AC profile

In capture make the AC profile active. Run the AC profile. In the PSpice window open view/Measurement Results. Select Trace/Evaluate Measurements. In the right frame select cutoff low pass 3dB and then click V(VOUT) from the left frame. See Fig. 14.

mmeybodi@aut.ac.ir



Fig. 14 Snapshot of the measurements window[4].

Simulate the DC profile and similarly trace W(Q1) and I(Q1:C) values. Return to capture. Select PSpice>Advances analysis>Sensitivity. Following results are displayed. See Fig. 15 and Fig. 16.

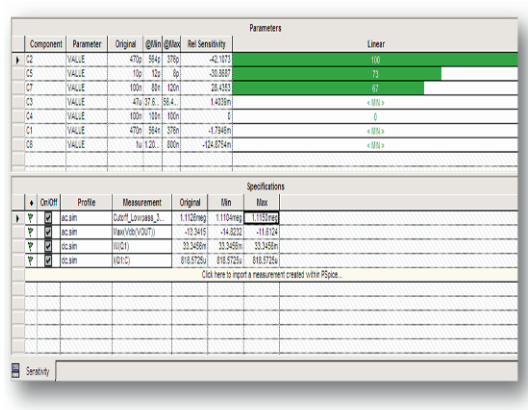


Fig. 15 Sensitivity Display

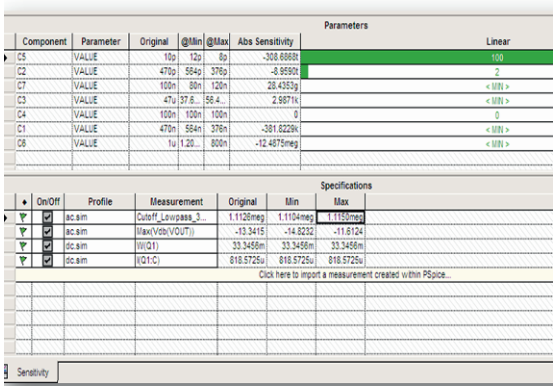


Fig. 16 Absolute vs Relative sensitivity

Similarly Sensitivity can be evaluated for Gain, Power and Collector current. See Fig. 17.

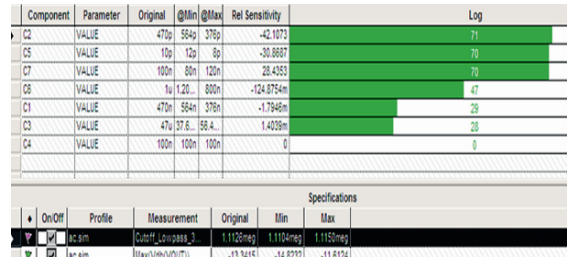


Fig. 17 Sensitivity of the various parts with respect to Bandwidth

IV. CONCLUSION

In conclusion the use of this analysis is very valuable. A lot of time energy and resources can be saved by a simulation that is more close to testing than it has ever been in case of printed circuit Boards. It gives an added advantage of predicting a myriad of situation that would take individual set-ups.

The advance analysis of PSpice allows Electrical, Computer and Audio Engineering students to better comprehend, visualize and simulate an electronic circuit prior to prototyping it, this design technique reduces production cost tremendously.

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mmeybodi@aut.ac.ir

Assessment of Size Effects on Efficiency

Sangchan Kantabutra
School of Management
Mae Fah Luang University
333 Moo.1, Thasud, Muang
Chiangrai, 57100, Thailand

Abstract-**This paper assessed size effects on efficiency using a nonparametric technique, data envelopment analysis and a Tobit regression analysis, respectively, for public upper secondary schools in Northern Thailand. Results show that school size contributes positively to both urban and rural schools, while class size has a positive effect on urban schools and a negative one on rural schools. A sensitivity analysis reveals the stability of class size and school size effects on efficiency. Policy to improve school efficiency should thus focus on expanding school size while reducing class size for rural schools.**

Key words: Size effects, Efficiency, Data Envelopment Analysis

I. INTRODUCTION

Thailand, one of the relatively fast-growing economies of Southeast Asia, has been providing the largest share of total public expenditure to education since 1991--even after the 1997 economic crisis began, the government provided 25% of total expenditures, or 4.3% of GDP, for education, which was a greater portion than before, demonstrating its commitment to education for the nation's recovery and development [1]. However, although the Thai government has committed significant resources, its degree of efficiency in providing educational services and procedures is still unclear [1].

This study employs a non-parametric technique, data envelopment analysis (DEA), to assess efficiency of public general upper secondary schools in Northern Thailand. DEA has been recognized as a useful management tool that can be applied for evaluating the relative efficiency of various organizations, e.g., hospitals [2], banks [3], or schools [4], as it compares a given unit to the best-performing units in its peer. The results obtained can identify relatively efficient/inefficient organizations and allow policy makers to develop performance-based policies to assist inefficient ones to improve their performance.

This study is to estimate school efficiency, investigate size effects and ascertain the robustness of size effects on efficiency. Size can impact school efficiency on curricula, teacher-student interactions, extra-curricular activities, student attentiveness and achievement [[5], [6], [7]]. Since a prototype of classroom and school size equity has affected Thai secondary schools [8], improvements in these areas can improve school efficiency.

This paper begins with the theoretical and empirical studies of size effects on school efficiency. It then goes on the analytical framework and the data and results. The paper ends by providing conclusions and recommendations.

II. EFFECTS OF SIZE ON SCHOOL EFFICIENCY

The size of a school is another important factor when discussing on school efficiency. There are apparently disadvantages to an organization being either too small or too large. Meier [9] identified size as the chief structural feature of an organization and stated that an organization's size affects the lives of its members. On organizational structure, Reference [10] noted the "centrality of size as a 'prime mover' of variation in the morphology of organizations". They also acknowledged that the attributes of educational organizations related to size affect the educational process.

Educators have generally accepted industrial principles of mass, efficiency and economies of scale [11]. Applying this concept to school operations leads to the conclusion that larger schools gain advantages into three areas: (1) more cost effectiveness, (2) a broader range of curricula become economically feasible, and (3) lower per-student expenditure [[12], [13]]. Although large schools often offer more courses, many of the additional courses are introductory or vocational in nature rather than enrichment in areas such as mathematics, science, or foreign languages [14]. However, small school proponents maintain that student achievement improves because smaller schools have higher class and school participation, parental involvement, attendance, and graduation rates, more individual attention, and a lower dropout rate [15]. Moreover, small schools can narrow the achievement gap across ethnicities and socioeconomic backgrounds [16]. Interestingly, there may be more evidence that small school size is associated with positive social outcomes [9].

Although size of the school influences student achievement, class size is perhaps more vigorously debated in terms of educational consequences [17]. As the number of students in class increases, the amount of time that teachers spend in procedural and internal matters, e.g., taking attendance, or domestic duties, e.g., accidents, increases [18]. Consequently, teachers in large classes spend more time on classroom management and experience more discipline problems [7]. In turn, small classes create classroom conditions that afford students opportunities to participate, learn and achieve socially and academically [19]. Moreover, some proponents regard

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 467–472.
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class size reduction as a measure for improving the achievement of disadvantaged students [[20], [21]].

Several studies have used DEA to measure the size effects on school efficiency. Reference [22] found no school size effect and a negative class size effect on efficiency for senior secondary schools in Finland. Reference [23] found a positive school size effect and a negative class size effect on efficiency for secondary schools in England. However, when the size was too small or too large, Reference [22] found an inverse relationship between size and efficiency.

III. The Analytical Framework

Examining the size effects on school efficiency would entail: (1) assessing school efficiency, (2) investigating size effects on efficiency, and (3) examining the robustness of size effects on efficiency. The data envelopment analysis (DEA), a non-parametric technique, is used to assess school efficiency, through viewing schools as productive units using multiple inputs to generate multiple outputs [24]. DEA has been used as an important approach to assess school internationally [[23], [22], [25], [4], [26]] and proposed to measure Thai school efficiency [[27], [28], [29]]. DEA is extensively used as a popular educational management tool due to its several unique advantages over other traditional techniques, e.g., ratio and regression analysis [30].

Using the DEA technique to assess school efficiency, schools are considered as production or decision-making units (DMUs). According to the Fig. 1, a production process is a mechanism in which educational resources (e.g., controllable and uncontrollable inputs) are used to produce outputs or outcomes. From this framework, inefficiency of school units can be caused by poor educational production mechanisms, uncontrollable environmental factors over the production process, or both. A model of a school production function might have, for example, three inputs (x_1, x_2, x_3) and three outputs (y_1, y_2, y_3). For this study, schools in the sample are divided into urban or rural. Each DMU's efficiency is measured twice: 1) relative to its own separate frontier (Separate Efficiency) or, in other words, measured within its own group, and 2) relative to the pooled frontier (Pooled Efficiency), or measured within the pooled sample.

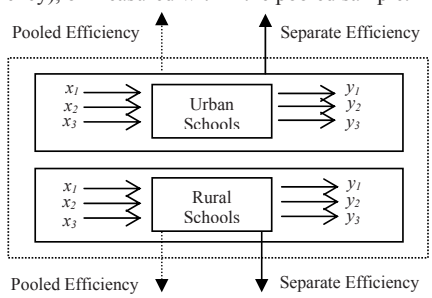


Fig. 1. Measurement of School Efficiency

The output maximization DEA model measures the extent to which outputs could be expanded for a given set of inputs [31]. In the context of public schools, Reference [25] noted that an output maximization DEA model was benefits to public schools since school principals should be oriented towards obtaining the best results on the basis of the resources available to them. A number of studies including Reference [[25], [23], [4], and [32]], used the output-oriented efficiency. For calculating efficiency, the DEA technique can be carried out by solving an output-oriented linear programming, incorporating the assumption of constant returns to scale (CRS) technology in the following equation [(Eq. (1)].

$$\text{maximize: } Z_0 = \phi_0 + \varepsilon \left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right]$$

Subject to:

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ - y_{r0}\phi_0 = 0, \quad r = 1,\ldots,s;$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- - x_{i0} = 0, \quad i = 1,\ldots,m;$$

$$s_i^- \geq 0;\ s_r^+ \geq 0;\ \lambda_j \geq 0 \qquad (1)$$

where x_{ij} and y_{rj} represent the observed values of the ith input and the rth output for school j (j = 1, …, n); λ_j is the input and output weights of other schools; s_i^- and s_r^+ are the slacks; ϕ_0 represents the efficiency of the school being evaluated; ε, a small positive constant, guarantees that inputs and outputs are positive and that the slacks do not influence the target function Z_0.

For assessing all schools in the sample, Eq. (1) is n times, giving n sets of λ_j, one set for each school, to determine its relative efficiency. In an output-oriented DEA model, technical efficiency is measured by the reciprocal of the output distance function [[31, [32]]. The reciprocal of the direct output function gives the proportion by which all outputs can be expanded, given the inputs. This output-oriented DEA model implies that the efficiency score (ϕ) will be equal to or higher than 1. An efficiency score (ϕ) of 1, together with nil values for all the slacks, indicates efficiency, i.e., that the school being evaluated has obtained the maximum possible production on the basis of the limited resources are available to it and the conditions under which it operates. A score of higher than 1 indicates that the school being evaluated could increase its production by the proportion (ϕ -1) without changing its current resources.

The second step is to investigate the size effects on school efficiency using regression analysis in conjunction with DEA technique. This step uses the DEA efficiency scores from Eq.

mmeybodi@aut.ac.ir

(1) as the dependent variables and regresses such scores against the sizes as influencing factors on the DEA efficiency scores in regression analysis. As the DEA efficiency scores from Eq. (1) have a lower bound of 1, the dependent variable of the regression analysis is made a censored variable. A Tobit regression model was deemed as an appropriate model and used for regressing the censored dependent variables in this case [[23], [22]]. For computation purpose in a standard Tobit model, the efficiency scores were transformed into inefficiency scores (efficiency-1) and then regressed as dependent variables in the following Tobit model [Eq. (2)].

$$\begin{aligned} \text{Ineff}_i^* &= \beta \cdot X_i + u_i \qquad i = 1, \ldots, \text{n}, \\ \text{Ineff}_i &= \text{Ineff}_i^*, \quad \text{if} \quad \text{Ineff}_i^* \geq 0 \\ \text{Ineff}_i &= 0, \quad \text{if} \quad \text{Ineff}_i^* < 0 \end{aligned} \tag{2}$$

where Ineff_i is the technical inefficiency score of DMUi obtained from the first stage, β is the coefficient parameter for independent variable X_i and u_i is a normally distributed residual with mean 0 and variance σ^2, $\nu \sim \text{N}(0, \sigma^2)$, for school i = 1, .., n.

The third step is to test the robustness of size effects on efficiency. In addition to primal specification (Specification 1), two input-output specifications are adopted to examine whether additional modifications in the educational production function could result in substantive changes in the empirical findings of size effects on efficiency measures. In addition to primal specification (Specification 1), one of output variables is decomposed into 3 sub-variables in Specification 2. In Specification 3, one input variable is added. Consequently, the estimations of a Tobit regression analysis for all specifications are explored for the robustness of the effects on efficiency.

IV. Data and Results

Data came from 455 public general upper secondary schools that were in Northern Thailand in 2003. Data for this study were collected from the Ministry of Education (MOE), Student Loans Fund, National Statistical Office (NSO), and the schools themselves. The sample consisted of 149 urban schools and 306 rural ones, defining "urban" as being within municipal areas and "rural" as being outside such areas, since Thailand has no classification of "urban" or "rural" as such [33]. Followed the DEA requirement, all of these schools were under the same regulations of the Office of the Basic Education Commission (OBEC) of the MOE and utilized the same curriculum, thus ensuring homogeneity across the schools, and that all schools had the same educational production technology.

Evaluators of school efficiency must consider not only controllable input variables, which are the educational resources available to students, but also uncontrollable inputs which reflect different students' background, e.g., socio-economic and family status (SES) and outputs that reflect academic quantity and quality of the students [[23], [34], [35], [25], [4]].

Inputs (X_i) used here are the teacher-student ratio [[35], [25], [4]] and proportion of students not from low-income families [[23], [34], [35]], to reflect the quantity of resources available (e.g., teachers) and quality of raw materials (e.g., students). Because general upper secondary school lasts for three years, input data covers 2001-2003, measured as an average whenever possible. To measure school outputs (y_r), average national test scores [[35], [22], [25], [4]], the number of students who passed their grades after first and second year (average of 2001-02) or were moved up [[35], [22]], and number of graduates [[35], [22]] were included to measure school efficiency.

Two technical efficiency measures for each school using the output maximization linear programming [Eq. (1)] were carried out: 1) assessment when the sample was partitioned (Separate), and 2) measurement for the sample as a whole (Pooled); results are shown in Table 1. Efficiency measures indicate the degree to which output could be proportionally increased using the same amount of inputs. For instance, an efficiency score of 1.58 implies that outputs of the school in question could be expanded by 0.58, or 58%, (1.58 - 1) without consuming additional input.

Size variables (X_i) of the Tobit regression model [Eq. (2)] captures the size effects on efficiency. Class and school sizes could potentially impact school efficiency both positively and negatively, e.g., through economies of scale. To capture these possibilities, this study used the actual number of students per class and school size variable, or the total number of students enrolled in the school in question [[35], [22], [23]].

Results are presented in Table 2. Because the transformed efficiency scores (Ineff) are regressed, the sign of the coefficient is oppositely related to the direction of size variables on efficiency. The negative signs suggest a negative relationship between size and school inefficiency-- that is, the negative signs suggest a positive relationship between variables and efficiency.

TABLE 1
EFFICIENCY RESULTS

Efficiency measure	Urban schools Mean (S.D.)	Rural schools Mean (S.D.)
Separate	1.5855 (0.4308)	2.2726 (0.7527)
Pooled	2.0593 (0.7397)	2.3605 (0.7168)

mmeybodi@aut.ac.ir

The signs of the coefficients of class size are positive and significant for both separate and pooled efficiency measures of urban schools, with values of (-0.0290) and (-0.0444), and are negative and significant for both separate and pooled efficiency measure of rural schools, with values of (0.0152) and (0.0151), respectively.

These results suggest that urban schools with larger class size were more efficient than their rural counterparts with larger class size. The signs of the coefficients of school size are consistently positive and significant, indicating that both urban and rural schools with larger school size were more efficient than their smaller counterparts. The findings of school size effect on efficiency are consistent with [[36], [23]].

Sensitivity analysis was conducted to ascertain the robustness of the analytical framework and resulting measures of size effects on efficiency. For the first additional specification (specification 2), the national test scores (SAT) was decomposed into verbal, numerical and analytical ability scores from specification 1. In specification 3, the teaching aide-student ratio, was added as alternative school input in addition to specification 2. Efficiency scores of schools in the sample were calculated using the output-oriented DEA model (Equation 1) together with the two additional specifications of the school's production function. As a result, the estimations of the Tobit models for the three specifications are explored to test the size effects on efficiency.

The results of the size effects on efficiency for all three specifications are shown in Table 3. Signs of class size coefficients are negative and significant for both separate and pooled efficiency measures of city schools, and are positive and significant for both separate and pooled efficiency measure of country institutions in all three specifications.

Results suggest that city schools with larger class size were more efficient than those with smaller class size, whereas their country counterparts with larger class size were less efficient than those with the smaller ones, in all specifications. However, in this table, class size has no significant effect on efficiency when the schools are pooled. These findings may be interpreted to confirm that partitioning the sample by urban-rural locale is an alternative way to investigate class size effect on school efficiency.

For school size effect, the signs of the coefficients of school size are consistently negative and significant for both separate and pooled efficiency measures of schools in both locales and in all specifications, except for the separate efficiency measures of urban institutions in specifications 2 and 3. The empirical findings also suggest that the effect of school size is lower than that of class size in all efficiency measures. Therefore, the results of the sensitivity analysis suggest the robustness of analytical framework and the resulting measures of size effects on efficiency in this study.

V. Conclusion and Policy Implications

In this paper, the size effects on school efficiency are analyzed for public general upper secondary schools in Northern Thailand. The efficiency measures are assessed using the DEA approach and statistically analyzed to investigate the influence of size effects on efficiency. Results reveal that school size has a positive effect on both urban and rural schools. Class size has a positive effect on urban schools and a negative one on rural institutions, using both separate and pooled efficiency measures. In addition, the sensitivity analysis shows the robustness of size effects on efficiency for both school types.

Table 2
Estimation results Of The Tobit Models Explaining School Inefficiency

Variable	Urban Schools				Rural Schools			
	Separate		Pooled		Separate		Pooled	
	Coeff.	t value (P-value)	Coeff.	t value (P-value)	Coeff.	T value (P-value)	Coeff.	t value (P-value)
Constant	1.7048	8.0394** (0.0000)	2.9820	9.6248** (0.0000)	1.3698	7.2498** (0.0000)	1.3117	6.9219** (0.0000)
Class size	-0.0290	-4.1250** (0.0001)	-0.0444	-4.3288** (0.0000)	0.0152	2.0724* (0.0391)	0.0151	2.0725* (0.0391)
School size	-0.0002	-2.2701* (0.0247)	-0.0006	-5.0255** (0.0000)	-0.0021	-9.4263** (0.0000)	-0.0015	-7.1765** (0.0000)

* Significant at the 5% level.
** Significant at the 1% level.

mmeybodi@aut.ac.ir

TABLE 3
ESTIMATION RESULTS OF THE TOBIT MODELS EXPLAINING SCHOOL INEFFICIENCY FOR THREE SPECIFICATIONS

Specification	Variable	Urban Schools				Rural Schools			
		Separate		Pooled		Separate		Pooled	
		Coeff	t value (p-value)	Coeff	t value (p-value)	Coeff	t value (p-value)	Coeff	t value (p-value)
1***	Constant	1.7048	8.0394** (0.0000)	2.9820	9.6248** (0.0000)	1.3698	7.2498** (0.0000)	1.3117	6.9219** (0.0000)
	Class size	-0.0290	-4.1250** (0.0001)	-0.0444	-4.3288** (0.0000)	0.0152	2.0724* (0.0391)	0.0151	2.0725* (0.0391)
	School size	-0.0002	-2.2701* (0.0247)	-0.0006	-5.0255** (0.0000)	-0.0021	-9.4263** (0.0000)	-0.0015	-7.1765** (0.0000)
2	Constant	1.5881	7.8041** (0.0000)	2.6052	9.1501** (0.0000)	1.0586	5.9804** (0.0000)	1.0268	5.7951** (0.0000)
	Class size	-0.0293	-4.3435** (0.0000)	-0.0384	-4.0727** (0.0001)	0.0175	2.5628* (0.0109)	0.0164	2.4084* (0.0166)
	School size	-0.0001	-1.5925 (0.1135)	-0.0006	-4.7656** (0.0000)	-0.0018	-8.6712** (0.0000)	-0.0013	-6.4450** (0.0000)
3	Constant	1.3967	7.6664** (0.0000)	2.6471	9.3672** (0.0000)	0.9402	5.2045** (0.0000)	0.9104	5.0453** (0.0000)
	Class size	-0.0273	-4.5375** (0.0000)	-0.0409	-4.3772** (0.0000)	0.0184	2.6342** (0.0089)	0.0173	2.4940* (0.0132)
	School size	-0.0001	-1.6580 (0.0995)	-0.0006	-4.9348** (0.0000)	-0.0017	-8.316** (0.0000)	-0.0012	-6.2069** (0.0000)

*** Primal Specification, ** Significance at the 99% level of confidence, * Significance at the 95% level of confidence.

This study, if validated, may have wide implications for national education policy. If validated by further research, the findings could be used to prioritize schools for treatment. That is, for rural schools, smaller class size may benefit pupils, e.g., more teacher-student interaction or one-to-one teacher-pupil contacts [17], which helps to relieve learning difficulties of rural pupils with lower SES. However, reducing class size for rural schools may be effective even if there is no selection of students for a given classroom [37]. As such, policy-makers may focus, for rural schools, on reducing smaller but schools larger – while for urban institutions, making both classes and schools larger may be more efficient than at present. This study focused on the size effects on school efficiency only for a given period. Future research could focus on analyzing effects on efficiency over time and/or across subgroups or regions in a panel data setting. Moreover, future studies might refine the inputs and outputs based on the objectives of each school type.

ACKNOWLEDGMENT

Author would like to thanks Mr. Burin Kantabutra for editing and sharing his crucial insights throughout this research works.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

ASM++ Diagrams Used on Teaching Electronic Design

S. de Pablo, S. Cáceres, J.A. Cebrián
Department of Electronics Technology
University of Valladolid, Valladolid, Spain.
{sanpab,sancac,jesceb}@eis.uva.es

M. Berrocal
eZono AG
Jena, Germany.
manuel@ezono.com

F. Sanz
European University
"Miguel de Cervantes", Valladolid, Spain.
fsanz@uemc.es

***Abstract*– Algorithmic State Machines are a 40-year old tool for the design of digital circuits. They are a good alternative to Finite State Machines, where only states can be properly described, but all operations must be annotated as lateral comments. This paper shows the inner relationship between ASM diagrams and modern languages used to describe hardware and it proposes several modifications to the standard methodology to allow automated tools to produce Verilog or VHDL code from these diagrams. The new notation is more complete and consistent and thus more convenient for CAD tools.**

I. Introduction

The Algorithmic State Machine (ASM) method for specifying digital designs, in an abstract behavioral form, was originally documented by Clare [1] who worked at the Electronics Research Laboratory of Hewlett Packard Labs, based on previous developments made by Osborne at the University of California at Berkeley [2]. Since then it has been widely applied to assist designers in expressing abstract algorithms and to support their conversion into hardware [3]. Many texts on digital logic design cover the ASM method in conjunction with other methods for specifying Finite State Machines (FSM), namely state tables and state diagrams [4]. Whereas most designers simply use them as a means to specify the control of digital systems using complex FSM models [5], [6], [7], [8], few texts actually use them to design whole systems, except [9] and [10], that actually increment their possibilities with higher level features.

State diagrams do not describe properly the actions that must be executed as the control unit evolves through different states. Meanwhile, ASM are a good alternative because they prevent inconsistent diagram specifications and they are easier to read and maintain. However, most authors consider them impractical for large algorithms and hard to manage because of their graphical interface [11], so modern hardware description languages (HDL) are usually preferred to design at the register transfer level (RTL).

Our engineering students at the University learn basic electronic design using schematic capture tools and later on they increment their skills on more complex RTL designs using VHDL and Verilog. We have seen that FSM are useful to give the students an overall view of a design, but they are limited for detailed descriptions. Additionally, we have found that ASM diagrams are useful during the concept capturing of a digital development [5], because it is easy to materialize ideas using them. During the detailed design specification, when the order between different tasks becomes complex or confuse, these diagrams help clarifying the ordering and interactions between tasks.

However, we have found that current ASM notation cannot properly describe real-life circuits, which usually have several FSM running in parallel with complex interactions between them. This paper presents a different notation, called "ASM++ diagrams", aiming to improve ASM for more complex designs and more suitable for automatic conversion into HDL code.

II. Traditional ASM Diagrams

Traditional ASM diagrams use three types of boxes: the "state boxes" –with rectangular shape– define the beginning of each clock cycle and may include unconditional operations that must be executed *during* or *at the end* of that cycle; "decision boxes" –diamond ones– are used to test inputs or internal values to determine the execution flow; and finally "conditional output boxes" –oval ones– indicate those operations that are executed only when previous conditions are valid. An "ASM block" includes all operations and decisions that are or can be performed simultaneously during each execution cycle.

These ideas are illustrated in fig. 1, where a 12x12 unsigned multiplier has been implemented through additions and shifts using two states: during 'Idle' state this circuit waits for two new operands given at 'inA' and 'inB' inputs when the 'go' signal is asserted to one; the second state, named 'Loop', executes twelve additions and shifts in twelve clock cycles to compute the desired product. At the end, a 'done' signal validates the result given at the output 'outP'. This circuit is asynchronously initialized using an active high signal called 'reset' and then it is synchronized with a 'clk' signal not included in this diagram.

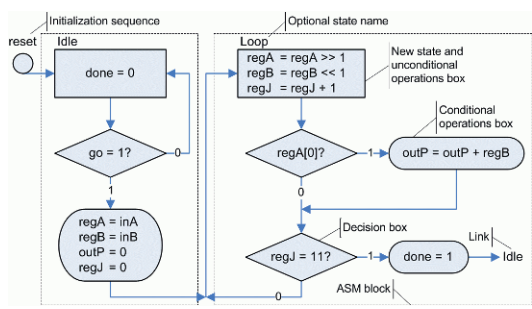


Fig. 1. An example of traditional ASM.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 473–478.
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mmeybodi@aut.ac.ir

The advantages of this representation over FSM are evident: not only the evolution between states has been described, but also the operations in and between states have been included; additionally, conditions can be built up incrementally and later combined into a single boolean condition [5]. However, they have several properties that may be seen as disadvantages:

- They use the same box –with rectangular shape– for new states and unconditional operations executed at those states. Because of this property, ASM diagrams are compact, but they are also more rigid and difficult to read.
- Sometimes it is difficult to differentiate the frontier between different states. The complexity of some states requires the use of dashed boxes (named ASM blocks) or even different colors for different states.
- Due to the double meaning of rectangular boxes, conditional operations must be represented using a different shape, the oval boxes. But, actually, all operations are conditional, because all of them are state dependent.
- Additionally, designers must use lateral annotations for state names, for reset signals or even for links between different parts of a design (see fig. 1).
- Finally, the width of signals and ports cannot be specified when using the current notation.

The new notation proposed in this paper tries to solve all these problems.

III. Basic Features of ASM++ Diagrams

The first and main change introduced by this new notation, see fig. 2, is the use of a specific box for states –we propose oval boxes, very similar to those circles used in bubble diagrams– so now all operations may share the same rectangular box. Diamonds are kept for decision boxes because they are commonly recognized and accepted.

As shown in fig. 2, the resulting ASM++ diagram is less compact, but more clear and flexible. Former ASM blocks become useless because limits between states are clearly defined by state boxes. All lateral annotations have disappeared when using the new notation and designers have more freedom to write operations using any arbitrary order: all operations written from one state to the next one are executed in parallel, but sometimes unconditional operations are better written *after* conditional ones, as shown in 'Loop' state where shifts are specified below the conditional addition. The use of a specific box for states also simplifies the use of links between different parts of a diagram. This feature helps in writing complex designs that cannot fit in a single page.

More boxes are described in the following section, but an important property of ASM++ can be pointed out now: all boxes use standard HDL expressions, either Verilog (this case) or VHDL (see fig. 6). This feature helps during the phase of handwriting the final HDL code, but also it is decisive for the ASM++ compiler that is in progress: it will generate HDL code for simulators and synthesizers based on these diagrams.

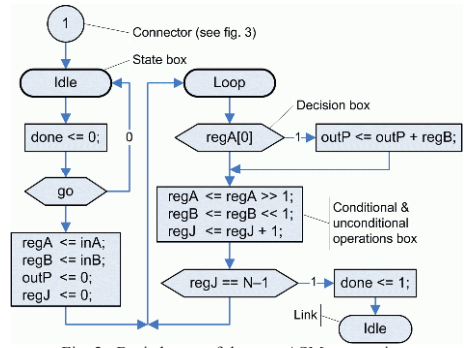


Fig. 2. Basic boxes of the new ASM++ notation.

The following code (see also fig. 3 to complete the circuit definition) shows how ASM++ diagrams can be easily translated into HDL code. After a quick look the correspondence between this diagram and its code is evident.

```
parameter  N = 12;                              // See fig. 3
// …
parameter  Idle = 1'b0,  Loop = 1'b1;           // State codes
always @ (posedge clk or posedge reset)         // See also fig. 3
begin
    if ( reset ) begin                  // Initialization sequence
        done <= 0;                          // Indicated by designer
        state <= Idle;                      // Going to the first state
    end else case (state)

        Idle:                           // First state
        begin
            done <= 0;
            if ( go ) begin                 // Waiting for 'go'
                regA <= inA;                // 12 bits assignment
                regB <= inB;                // 24 bits assignment
                outP <= 0;                  // 24 bits assignment
                regJ  <= 0;                 //  4 bits assignment
                state <= Loop;              // Jump to next state
            end
        end

        Loop:                           // Second state
        begin
            if ( regA[0] )
                outP <= outP + regB;    // Conditional operation
            regA <= regA >> 1;          // Unconditional operations
            regB <= regB << 1;          // The order …
            regJ  <= regJ + 1;          // … is decided by user
            if ( regJ == N–1 ) begin
                done <= 1;              // Indicate it finishes
                state <= Idle;          // Conditional jump
            end
        end

        default:                        // Because of security reasons
            state <= Idle;

    endcase
end     // always block
```

IV. Additional Features of ASM++ Diagrams

Figure 2 describes the internal architecture of the proposed module, but says nothing about its external interface, the width of internal signals, or about synchronization. For an automated

mmeybodi@aut.ac.ir

tool that generates HDL code from this specification other boxes are clearly required. Therefore, the new ASM++ notation adds more boxes to face these requirements, as shown in fig. 3. Though, this paper modifies what was proposed at [12] and [13].

From up to down, the first box of fig. 3 specifies the design name ("multiplier") and its optional parameters (or *generics*, using the VHDL notation). Following, a port-like box allows a detailed definition of the module interface: all inputs and outputs can be described using the preferred HDL language. Obviously, bigger designs may use more than one of these interface boxes.

The third box has a card-like shape and is used to introduce general HDL code and compiler directives: in this case, it is used to declare and specify the size of all internal signals (except the variable used for the resulting state machine).

Afterwards, a small box indicates that the synchronism of this whole circuit will be managed using the 'clk' signal, and finally the active high 'reset' signal will be used to asynchronously initialize the 'done' output and the internal state, starting at the first state named 'Idle' (see also fig. 2).

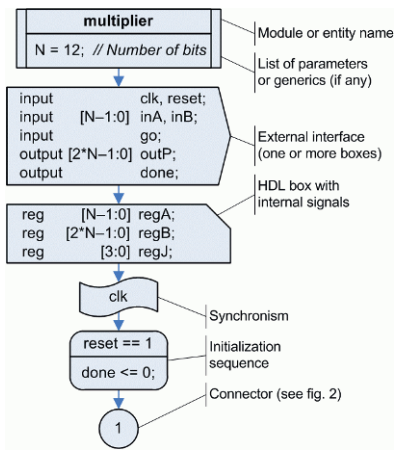


Fig. 3. Additional ASM++ boxes required to generate HDL code.

Using these new boxes, designers are now capable of completely describe a module and generate the subsequent HDL code for simulation and synthesis. However, looking with greater attention to the signals of these diagrams, we found that all of them exhibit a synchronous behavior: all operations included in rectangular boxes are registered *at the end* of each clock cycle. To improve the designer possibilities, a new box for asynchronous assertions is also provided: they have bent sides, as shown on fig. 4, and describe operations that are performed *during* the present clock cycle.

Furthermore, a new box to describe default values has been included: when synchronous signals are not used in one or more states, the default behavior of those signals must be *to keep constant* their last value, and that is the way all VHDL and Verilog compilers work. But what happens when an asynchronous signal is not used in one or more states? The proposed value for those situations is *"don't care"* to minimize the generated combinatorial logic (see for example the HDL code for 'data_out' on fig. 4, it actually does not depend on the value of 'pop'). A new box has been included to modify these default behaviors, for synchronous and asynchronous signals; otherwise, designers would be required to write their specifications once and again.

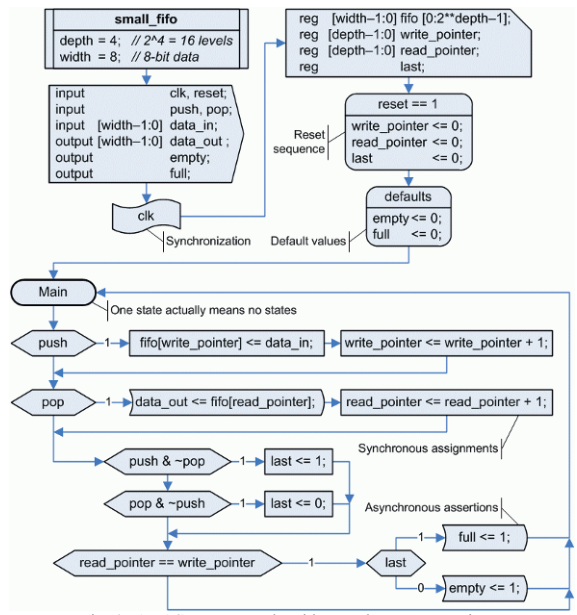


Fig. 4. An ASM++ example with asynchronous assertions.

The full Verilog code for the diagram of fig. 4 is shown following. It should be noted that asynchronous assertions ought to be written *out of* the 'always' (or 'process') block, because they are not sensible to 'clk' edges or to 'reset' signal.

```
module small_fifo (clk, reset,
                   push, pop, data_in, data_out, empty, full);

  parameter  depth =  4;                  // It means 2^4 = 16 levels
  parameter  width  =  8;                 // 8-bit data width

  input                    clk, reset;
  input                    push, pop;
  input    [width–1:0]     data_in;
  output   [width–1:0]     data_out;
  output                   empty, full;

  reg      [width–1:0]     fifo  [0:2**depth–1];
  reg      [depth–1:0]     write_pointer;
  reg      [depth–1:0]     read_pointer;
  reg                      last;

  always @ (posedge clk or posedge reset)
  begin
      if (reset) begin
          write_pointer    <= 0;          // Initialize pointers
          read_pointer     <= 0;
          last             <= 0;
      end
```

mmeybodi@aut.ac.ir

```
        else begin
            if (push)     write_pointer <= write_pointer + 1;
            if (pop)      read_pointer <= read_pointer + 1;

            if       (push & ~pop)    last <= 1;
            else if (pop & ~push)     last <= 0;
        end
    end

    always @ (posedge clk)
    begin
        if (push)  fifo[write_pointer] <= data_in;
    end

    assign data_out = fifo[read_pointer];

    assign empty = (read_pointer == write_pointer) & (last == 0) ? 1 : 0;
    assign full  = (read_pointer == write_pointer) & (last == 1) ? 1 : 0;
endmodule    /// small_fifo
```

The main reason for differentiating synchronous assignments –codified into an 'always' block– from asynchronous assertions –codified out of it, is that when code is handwritten [14], [15], designer must look for all assertions *after* the main block is written down. In order to understand the behavior of the circuit, a different shape also helps.

V. Hierarchical Design using ASM++ Diagrams

A top level example with a hierarchical design is shown in fig. 5. It includes all previous modules to build a 12x12 multiplier with two input FIFOs and an output FIFO to maximize its throughput. As can be seen, when a module is instantiated in an ASM++ diagram, the proposal is that a full set of signals (with the name of the instantiated module, a dot, and the name of each module port) are automatically available to easy its connections with other modules. The result is clear, as can be seen below, and designers write only what they need.

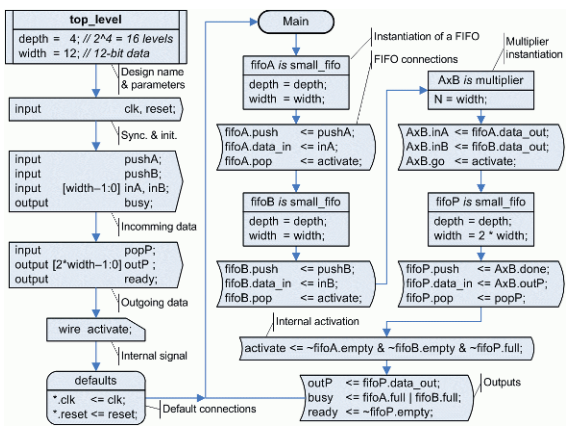


Fig. 5. A hierarchical design using ASM++ diagrams.

The Verilog code for the diagram of fig. 5 is shown at the right column. The relationship between diagrams and HDL code becomes evident again. It is also remarkable the amount of code saved when using ASM++ diagrams, because most redundant lines required by Verilog and VHDL are avoided.

```
module top_level (clk, reset,
                  pushA, pushB, inA, inB, busy,
                  popP, outP, ready);
  parameter  depth =  4;              // 16 levels at each FIFO
  parameter  width = 12;              // 12-bit unsigned integer

  input                    clk, reset;

  input                    pushA, pushB;
  input      [width–1:0]   inA, inB;
  output                   busy;

  input                    popP;
  output [2*width–1:0]     outP;
  output                   ready;

  wire                     activate;     // Internal signal

  wire                fifoA_clk, fifoA_reset;
  wire    [width–1:0] fifoA_data_in, fifoA_data_out;
  wire                fifoA_push, fifoA_pop, fifoA_empty, fifoA_full;
  small_fifo  # (depth <= depth, width <= width)  fifoA  (
    .clk(fifoA_clk), .reset(fifoA_reset),
    .push(fifoA_push), .pop(fifoA_pop), .data_in(fifoA_data_in),
    .data_out(fifoA_data_out), .empty(fifoA_empty), .full(fifoA_full) );

  wire                fifoB_clk, fifoB_reset;
  wire    [width–1:0] fifoB_data_in, fifoB_data_out;
  wire                fifoB_push, fifoB_pop, fifoB_empty, fifoB_full;
  small_fifo  # (depth <= depth, width <= width)  fifoB  (
    .clk(fifoB_clk), .reset(fifoB_reset),
    .push(fifoB_push), .pop(fifoB_pop), .data_in(fifoB_data_in),
    .data_out(fifoB_data_out), .empty(fifoB_empty), .full(fifoB_full) );

  wire                AxB_clk, AxB_reset, AxB_go, AxB_done;
  wire    [width–1:0] AxB_inA, AxB_inB;
  wire  [2*width–1:0] AxB_outP;
  multiplier  # (width)  AxB  (
    .clk(AxB_clk), .reset(AxB_reset),
    .inA(AxB_inA), .inB(AxB_inB), .go(AxB_go),
    .outP(AxB_outP), .done(AxB_done) );

  wire                fifoP_clk, fifoP_reset;
  wire  [2*width–1:0] fifoP_data_in, fifoP_data_out;
  wire                fifoP_push, fifoP_pop, fifoP_empty, fifoP_full;
  small_fifo  # (depth <= depth, width <= 2 * width)  fifoP  (
    .clk(fifoP_clk), .reset(fifoP_reset),
    .push(fifoP_push), .pop(fifoP_pop), .data_in(fifoP_data_in),
    .data_out(fifoP_data_out), .empty(fifoP_empty), .full(fifoP_full) );

  assign  fifoA_clk    = clk;          // Default connections
  assign  fifoB_clk    = clk;
  assign  AxB_clk      = clk;
  assign  fifoP_clk    = clk;
  assign  fifoA_reset  = reset;
  assign  fifoB_reset  = reset;
  assign  AxB_reset    = reset;
  assign  fifoP_reset  = reset;

  assign  fifoA_push     = pushA;      // User connections
  assign  fifoA_data_in  = inA;
  assign  fifoA_pop      = activate;

  assign  fifoB_push     = pushB;
  assign  fifoB_data_in  = inB;
  assign  fifoB_pop      = activate;

  assign  AxB_inA        = fifoA_data_out;
  assign  AxB_inB        = fifoB_data_out;
  assign  AxB_go         = activate;

  assign  fifoP_push     = AxB_done;
  assign  fifoP_data_in  = AxB_outP;
  assign  fifoP_pop      = popP;

  assign  activate = ~fifoA_empty & ~fifoB_empty & ~fifoP_full;
  assign  outP     = fifoP_data_out;
  assign  busy     = fifoA_full | fifoB_full;
  assign  ready    = ~fifoP_empty;
endmodule    /// top_level
```

mmeybodi@aut.ac.ir

VI. Parallel Threads on ASM++ Diagrams

Operations at any state are (conditionally) executed in parallel. However, real life circuits usually need two or more state machines also running in parallel [13], with dependent or independent state sequences. ASM++ diagrams introduce that feature, as shown in fig. 6. This example uses VHDL to describe a simplified version of a dual-clock FIFO, with no flags, and also VHDL is used for the generated code.

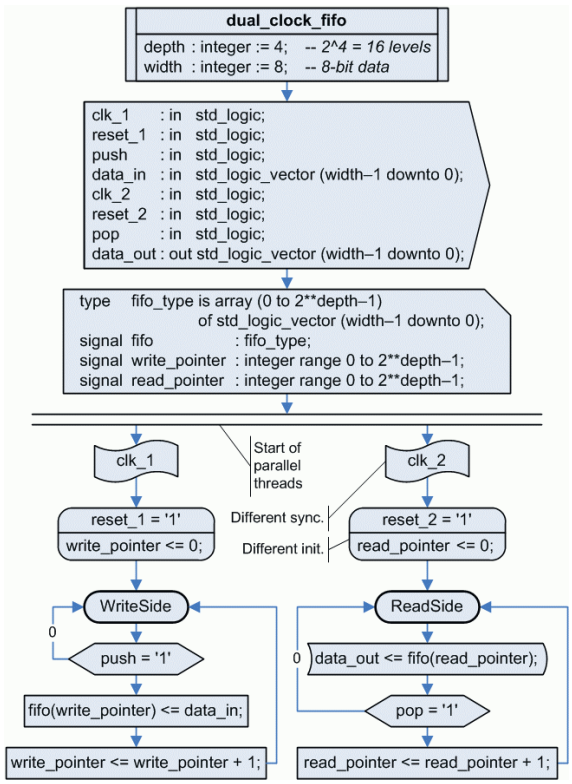


Fig. 6. A two threaded design with two clock signals.

The VHDL code that implements the functionality described on fig. 6 is shown following.

```
library  IEEE;
use      IEEE.std_logic_1164.all;

entity dual_clock_fifo is
  generic (
    depth  : integer := 4;    -- 2^4 = 16 levels
    width  : integer := 8     -- 8-bit data
  );
  port (
    clk_1, reset_1, push    : in  std_logic;
    data_in                 : in  std_logic_vector (width–1 downto 0);
    clk_2, reset_2, pop     : in  std_logic;
    data_out                : out std_logic_vector (width–1 downto 0)
  );
end dual_clock_fifo;
```

```
architecture RTL of dual_clock_fifo is
  type      fifo_type is array (0 to 2**depth–1)
                of std_logic_vector (width–1 downto 0);
  signal    fifo              : fifo_type;
  signal    write_pointer     : integer range 0 to 2**depth–1;
  signal    read_pointer      : integer range 0 to 2**depth–1;
begin
  process (clk_1, reset_1)            -- Write pointer control
  begin
    if (reset_1 = '1') then
      write_pointer <= 0;
    elsif rising_edge(clk_1) then
      if (push = '1') then
        write_pointer <= write_pointer + 1;
      end if;
    end if;
  end process;
  process (clk_1)                     -- Writing of the FIFO
  begin
    if rising_edge(clk_1) then
      if (push = '1') then
        fifo(write_pointer) <= data_in;
      end if;
    end if;
  end process;
  process (clk_2, reset_2)            -- Read pointer control
  begin
    if (reset_2 = '1') then
      read_pointer <= 0;
    elsif rising_edge(clk_2) then
      if (pop = '1') then
        read_pointer <= read_pointer + 1;
      end if;
    end if;
  end process;
  data_out <= fifo(read_pointer);   -- Asynchronous FIFO output
end RTL;  --- dual_clock_fifo
```

VII. Conclusions

This article has presented a powerful graphical method for electronic design at register transfer level. It is based on standard ASM diagrams and most used structures of modern hardware description languages when implementing FPGA designs, improving their possibilities.

The resulting graphical language is easy to learn and it allows a quick circuit behavior understanding, thus it is a suitable representation for design supervision and documentation. It also has demonstrated that it is an excellent medium for teaching electronics, as a means of describing the circuit functionality before schematic capture or HDL handwriting.

However, this is an ongoing methodology and new boxes with advanced functionality will be added in a near future. An ASM++ compiler for Verilog and VHDL is under active development.

Acknowledgments

The authors would like to acknowledge the financial support for these developments of eZono AG, Jena, Germany.

mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Using Platform Virtualisation to Teach System Architectures in Undergraduate Computer Science – An Evaluation of Student Learning Experiences

Sean Duignan, Tony Hall
National University of Ireland
Galway, Ireland.
sean.duignan@gmit.ie tony.hall@nuigalway.ie

Abstract– **This paper describes a learning design intervention conducted by the researchers with a group of undergraduate *Business Computing* students studying operating systems. The purpose of the study was to attempt to enhance the learning experience of students on the practical / architectures aspect of their operating systems curriculum. Machine / platform virtualisation was used to provide a more realistic laboratory environment for the students; one in which they could interact with the machine with full 'administrator' privileges in an unrestricted manner. In contrast to other studies on the use of virtualisation in the classroom, the authors focus on the *student* learning experience, and not on the instructor or laboratory supervisors' perspective on using virtualisation tools. To that end, feedback provided by the students on their learning experience with the virtualisation tool is presented. In addition, a comparison is made with feedback data from situations where no virtualisation was used. The data suggests that virtualisation had a positive impact on the learning experiences of those who participated in the study. The authors also reflect on the notion of 'productive failure' and posit that virtualisation may have a pivotal role to play in a pedagogy that facilitates the co-existence of scaffolded learning and (unscaffolded) productive failure.**

INTRODUCTION

This paper describes a teaching and learning study conducted with a group of 24 undergraduate computer science students over a 12-week period between March and May 2007. The group was comprised of a class of third-year students studying *operating systems* as part of a *'Bachelor of Science (Business Computing)'* degree. The focus of the study was to investigate the potential of *platform virtualisation* as an aid to teaching and learning in the practical aspects of the *architectures* component of their *operating systems* curriculum. Platform virtualisation software products allow for the creation and execution of multiple *virtual machines* (frequently referred to as *virtual appliances)*, running in isolation, side-by-side, on the same physical machine. Each virtual machine has its own set of (virtual) hardware (CPU, RAM, DVD-ROM, Network Interface etc.) upon which an operating system and application base can be loaded. Within each virtual machine, the operating system sees a consistent collection of hardware, independent of the actual physical hardware components. As these virtual machines are 'contained' within the virtualisation software, virtual machines can be created, destroyed, modified, interconnected, and cloned without affecting software applications or hardware resources outside of the virtualisation 'container'.

While neither the researchers nor the students involved in this study had any prior experience in the use of virtualisation, given the characteristics of virtualisation / virtual machines, it was felt that there was scope for its use in an educational context, particularly in computer science subject areas that can benefit from the existence of a rich experimental laboratory environment for practical sessions. Indeed, this point was crucial in deciding to design a learning intervention using virtualisation – the (ongoing) provision of a rich experimental laboratory environment for practical sessions is extremely difficult to realise at many higher education facilities, including ours. In subject areas such as *operating systems* (among others), the ability to interact with the *actual* machine, in order to visualise and configure its core components is a useful aid to understanding and to learning. Unconstrained, direct interaction with a computer system may enrich the learning experience and may also provide a suitable practical balance to complement theoretical concepts learned in the classroom. A difficulty posed in the classroom and laboratory however is that oftentimes, useful practical activity can be quite 'destructive' in its nature, as well as being resource intensive and time consuming. Constructing an *n-tiered* architecture to physically host an information system, installing operating system and database platforms, partitioning fixed disks, implementing a cluster of machines etc… are all somewhat destructive in their nature. In a college laboratory environment, a further mitigating factor is the typical requirement to leave the machines in a specific and useable state for the next users of the laboratory. Furthermore, subject-specific dedicated hardware and laboratory space can be difficult to come by, particularly as there will be a limited use of such resources. Such issues provided a practical and pedagogical motivation to seek a cost-effective technology solution that could improve on the current situation.

THEORETICAL BACKGROUND

Fundamentally, the authors are interested in a meaningful application and use of technology in the teaching and learning of the computer science curriculum in higher education. *'Meaningful application and use'* should support, and be supported by, established theories of learning and pedagogy.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 479–484.
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mmeybodi@aut.ac.ir

With regard to the research described in this paper, the learning theories that underpin our work include constructivism and constructionism [1], [2], [3], [4] activity theory [5], active learning, sociality [6], and collaboration. These theories effectively embody an ethos of learning by doing, and by experiencing for one-self, in an engaging social setting. Building on this theoretical foundation we seek to provide a learning environment in which diversity of learning context, the notion of a 'spiral curriculum' [7], the development of 'habits of the mind' in learners [8], [9], and the notion of productive failure [10], [11] are all possible, and are to be encouraged. We are particularly influenced by *constructionism*; an educational method which proposes that people learn most effectively through making things. Constructionism suggests that students will be more deeply involved in their learning if they are constructing something that others will see, critique, and perhaps use. It is further suggested that learning happens *"especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe"* [1]. Additionally compelling is Meier's philosophy of education, which encourages the development of five "habits of the mind" in learners [8]. These habits are crucial for exercising judgment on complicated matters and involve raising questions about: *Evidence, Points of View, Connections, Conjecture,* and *Relevance.* We sought to facilitate the development of these habits in students through the combination of an assigned project that encouraged such questioning, and the provision of a virtualised environment that allowed answers to be constructed.

Literature review

Much of the literature related to the use of virtualisation technologies in higher education focuses on the teaching experience from the instructors perspective or on the administrative convenience afforded by the solution, rather than on the learning experience of the student. Mattord and Whitman for instance, provide an overview of current practices employed in facilitating practical work in aspects of the *Information Security* curriculum [12]. Their review considers hardware, software, and lab design issues including terminal server options, multiboot systems, removable drives, internal subnetworks and NAT enabled solutions. They also consider the use of virtual images and recommend it as a best practice [12]. Nieh and Vaill describe the use of virtualisation to provide an environment for OS kernel development in a shared computing facility without affecting other users [13]. They argue the merits of virtualisation as an aid to *teaching*. They also note the popularity of this pedagogical approach with students by citing the increased enrolment in their annual 'elective' module in operating systems to such an extent that it is now offered every semester, and by 2004 (some three years into their use of virtualisation) had the highest enrolments of any Computer Science course at Columbia University. They do not however provide any description of feedback from students on their learning experiences using virtualisation. Stockman focuses on how virtualisation can be leveraged to more effectively teach computer networking and systems administration which he notes has traditionally been "*cumbersome and ineffective; and is almost always an expensive prospect when it comes to instructional and lab facilities*" [14]. Again the core focus of his paper is on instructional techniques and the configuration and deployment of the virtual solution(s). There is no discussion of or attempt at measuring the impact of the technology on the student learning experience. Likewise McEwan's paper focuses on the "how to" aspect of virtualisation in order to build a mixed physical and virtual laboratory facility which he concludes will be of increasing strategic importance in the e-learning education market [15]. The authors of [16] take a similar approach in their paper which deals with the application of virtualisation technologies to the teaching of network, security and database courses and deals primarily with the benefits and challenges in course and lab configuration – again very much an instructor centric perspective. While Dobrilovic and Stojanov in their 2006 paper identify "*students' response considering the exercise quality and measuring the level of adopted knowledge*" as an aspect of their future work, the principal focus of their paper is nonetheless the detailed description and analysis of the results of a number of technical experiments within the field of operating system conducted in a virtualised environment [17]. Our paper presented herein is an effort to fill a gap in the literature by focusing on student learning experiences with virtualisation. Indeed the motivation to design a learning intervention using virtualisation was largely influenced by the desire to enhance the learning experience for the student (not the instructor), and informed by the theoretical influences discussed earlier.

Motivation for change

Rather than providing a weekly "controlled and bounded" lab session for students in which a specific task to be accomplished was assigned on the day, a capstone project was assigned at the start of the first laboratory session which could be progressively worked on over the 12 weeks, and which would be submitted at the end of the semester. This approach was in contrast to that of previous years in delivering the *operating systems* module. The change was primarily motivated by the authors sense of a "sterile" laboratory environment in the past incarnations of the delivery of this module; an environment in which experiments were described and perhaps cautiously demonstrated, but typically an environment in which students rarely experienced everything first hand and without constraint.

This sense of sterility was re-enforced by comments received from students who had completed the module in the past. As part of academic quality assurance procedures at the college where the research was conducted, at the end of the semester / year, each student completes an end of module survey (Form QA1) for every module they have taken. The forms, which are instances of a nationally agreed survey instrument, are completed anonymously, and seek to solicit the students personal ratings of a number of areas relating to the

mmeybodi@aut.ac.ir

module including *(i) Resource Availability, (ii) Organisation of Content (iii) Presentation of the Content* and *(iv) Effectiveness of Communications*. A fifth category seeks views / comments that serve as a *General Evaluation* and *Suggestions for Improvement*. Some 134 students of operating systems have completed QA1 forms over the six-year period from 2002 to 2007. Responses to questions within categories (i) through (iv) above follow a 4-point Likert scale. Collectively, within those categories there are a total of thirty questions relating to various aspects of the module and its delivery methods. A response of "1" represents the lowest rating while a "4" represents the highest rating in all cases. Category (v) above - *General Evaluation and Suggestions for Improvement* – allows for respondents to provide open-ended comments with respect to the positive and negative aspects of the module, in addition to allowing for suggestions for improvement.

Of the 18 students who completed QA1 forms for the *operating systems* module in the academic year 2005-06 (the year immediately preceding the virtualisation intervention described herein), 9 of them responded to questions relating to equipment range / equipment quality / laboratories / laboratory availability (all part of the *Resource Availability* section), with scores of "2" or lower. Only one student scored *Resource Availability* with the top rating of "4". Ratings of "4" were in more regular supply from students however for other aspects of the module (e.g. quality of lecture rooms, library reading materials, sequence of delivery, use of visual aids etc...). With regard to the open-ended feedback, 12 of the 18 students elected to comment. Of those who did, almost 75% of the comments relate to issues of practical / laboratory work. Comments such as *"More practicals needed", "Practical side is weak", "More lab sessions would improve the course"* are indicative of the typical comments received and echo many of those received in earlier years too. Having considered the ratings returned from students (*i.e.* the prevailing low ratings for laboratory equipment and availability), in addition to the comments provided, the authors suggest that the words *relevant* or *appropriate* might be inferred in many of the comments received (*i.e.* that more *relevant / appropriate* practicals are required). Therein was the challenge – "more" could be provided, but more of the same would not address the shortcomings. Providing more time in an under-resourced or inappropriate laboratory environment would not lead to an improvement in the students learning experience. Given the demand on financial and spatial resources, a dedicated laboratory environment for operating systems was not a realisable goal. All of these issues further prompted the investigation into the potential of a virtualised solution.

WORKING AND LEARNING IN THE VIRTUAL LABORATORY

After an initial demonstration of virtualisation software in action (we used *VMWare Player™* and *VMWare Workstation™* from VMWare Inc.), the instructional approach became very "hands off" from the instructors' perspective and "hands-on" for the student(s). Students were largely left to their own devices to experiment, to construct, to collaborate, to fail and to possibly succeed at tasks. Given the nature of *operating systems*, and in particular, the context of these sessions relating to *operating system architectures* within an overall degree program, where a core learning objective for the semester is the development of hands-on troubleshooting skills in desktop and enterprise operating systems, this pedagogical approach seemed appropriate. The initial demonstration illustrated the creation and subsequent manipulation of a *"full Windows XP (virtual) device"* on top of the existing physical device. It quickly became apparent that constructive, destructive and transformative tasks undertaken on the virtual device had no bearing on the underlying physical host. The purpose of the demonstration was to convey to students that the virtualisation tool was essentially providing them with a blank canvas upon which they could create and manipulate useable computer systems. After that, it was for them to use their canvas to realise their projects. The authors sensed an immediate and growing enthusiasm toward the virtualisation tools. This may have been due to the fact that "results" materialise very quickly when using the tools. A rudimentary virtual machine for instance, can be created in less than five minutes; at which point more advanced work such as configuration and installation of an operating system can begin. As such, the results of ones work are tangible and measurable from the outset. In addition, for the majority of the students, these sessions represented something very new to them; the configuration and manipulation of "the machine" at a low level. From theory classes, the principles were very familiar to them but the practical aspect had largely been devoid of any measurable experience up to this point. As is evidenced in the data collected and analysed later, for many students, this type of activity was what they expected to be doing when they signed up to a degree programme in computing. Now, they were doing finally doing it, unconstrained.

THE VIRTUALISATION ASSIGNMENT

For the purpose of continuous assessment, a project was assigned, focusing on the development of practical *'architectures'* skills in students. This project was assigned 30% of the overall mark for the *operating systems* module. Students were divided into project groups of typically two or three persons (one student elected to complete the assignment on his own). Interaction among and between groups was not discouraged. The specification of the project as assigned required each group to construct three separate Virtual Machines, each to a specific specification. Each machine ran a different operating system (the legacy *DOS V6.22*, *Windows™ XP Professional*, and *Ubuntu Linux* respectively). Each machine was to be configured to an exact (virtual) hardware specification, and each machine had a number of specific operating system configuration requirements relating to memory allocation, hard-disk division, file-system type, networking options, locale options and OS patches / service packs. Finally, the three machines belonging to the group were required to communicate with one another over a 'virtualised' local area network. The choice of three disparate operating systems (two modern operating systems from different ends of

mmeybodi@aut.ac.ir

the proprietary *versus* open source spectrum, and a legacy system of more limited functionality by comparison), along with the specific tasks of the assignment, were part of an effort on the instructors part to promote the pedagogy described earlier – one in which constructionist principles, sociality, collaboration and the development of (questioning) 'habits of the mind' might prevail.

The laboratory sessions timetabled for the module became dedicated time for working on the project. The flow of these one-hour sessions, which took place on Wednesdays from 12:00 to 13:00 and from 14:00 to 15:00 (most groups attended one session weekly, allowing for a more comfortable working environment in the 22-seater lab), was quite relaxed, indeed frequently ad-hoc, and in the authors opinion were more akin to an informal workshop than to a formal instructional session. No assessment of the various groups' assigned deliverables was conducted at any interim stage. Progress to date for the various groups could be inferred however, from the nature of the questions being asked (of the researcher, and of each other).

Of the 24 students that commenced the module, 20 of them participated to completion in a project group, and there were 9 group projects submitted in total. On the assumption that no group would be motivated to 'carry' a non-performing group member, all members of a group were given the same mark for the assignment, subject to each group member's name being included on all of the final submission material. In an effort to differentiate among the various submissions received and in order to also gain some qualitative insights into students learning experiences, each group was asked to submit a document detailing their insights and experiences (as a group) from working on the assignment. Specifically, the final part of the assignment noted: *"You should submit a brief document (e.g. 2 – 3 pages) outlining your insights / feedback from completing this project (e.g. was the whole exercise useful, what did you learn, has it helped your understanding of operating systems (and how?), etc…. This file should be named feedback.doc and should be stored on the root of the C drive of your windows XP (virtual) machine."*

The scope of the feedback element was left deliberately broad and students were assured that all feedback, from any perspective (objective, subjective, technical, qualitative, even "gut feelings") was encouraged. This element of the assignment was an opportunity for them to reflect on their own work submitted, to reflect on the *operating systems* curriculum in its entirety (theory and practical), as well as a way for them to potentially influence how teaching and learning with virtualisation might proceed on this module into the future.

The various tasks that made up the assignment were very precise in their description and nature, and as each group completed the specification to a high degree of satisfaction, the marks awarded to the groups were quite high. The authors note however that the quality of the work and artefacts produced was of a high standard, and that accordingly, the marks awarded were justifiable. Furthermore, learning objectives (the development of "low level" hands on skills in working and configuring operating systems), as evidenced by the work produced and submitted, appear to have been achieved. However, and so as not to court favour or a bias of any kind with the students, the end-of-module quality assurance forms (form QA1, described earlier) were distributed for completion and collection in advance of any marking or scoring of the assignment. The detail of these QA1 forms along with the detail of the 2 – 3 page "assignment feedback documents" received from the nine groups is considered in the next section.

STUDENT FEEDBACK

Of the 24 students who signed up for the operating systems module, 20 participated in the virtualisation project in its entirety, and 19 completed and returned (anonymous) QA1 end-of-module survey forms. While the QA1 solicits ratings for some thirty items in total, of most interest to the authors were the student's ratings of the *quality of laboratory facilities*. Interestingly, some 15 students (12 + 3) rated the quality of laboratory facilities (where the virtualisation tools were employed) at "3" or higher. Table 1 depicts the spread of responses / ratings for the current year and also includes the ratings provided by students in the previous year for comparative purposes.

Year	Module	Number of Respondents	Quality of Lab Facilities (1 is lowest rating, 4 is highest)			
			1	2	3	4
2005 / 2006	Operating Systems	18	2	7	8	1
2006 / 2007	**Operating Systems**	**19**	**-**	**4**	**12**	**3**

Table 1 – Student Ratings of the Quality of Laboratory Facilities
(Different student groups from two different years)

The authors acknowledge that the sample sizes are quite small, that other variables also need to be considered, and that consequently, an interpretation of the statistics presented in Table 1 may be somewhat subjective (indeed the process of *rating facilities* is in itself very subjective, and Table 1 is depicting such ratings from two different sets of students). Nonetheless there is a suggestion that the use of virtualisation technologies, through an enhancement of the scope and usability of the physical resources already in place, has the potential to improve students' perceptions of the quality of that laboratory. We argue then that this educational design intervention may have had some impact on student learning and that further investigation is warranted. This is also apparent from some of the comments received in the final part of the QA1 forms (2006 / 2007), where of the 9 students that

mmeybodi@aut.ac.ir

chose to comment, 7 commented positively on the usefulness of the practical / project to their learning.

That virtualisation has some merit with respect to laboratory enhancement is further suggested by a comparison of the same group's ratings of laboratory facilities before and after the virtualisation intervention. The group of students that participated in this virtualisation study from March – May 2007 as part of the *operating systems* module also studied a module in *practical networking* with one of the researchers as instructor between September and December 2006. No virtualisation technologies were used on the *practical networking* module; a module that is similar in many respects to the *operating systems* module. Specifically, it too, frequently requires the configuration and manipulation of "the machine" at a low level, and can benefit from such access being provided. Table 2 depicts the spread of responses for the rating of the quality of laboratory facilities by the same set of students over the two modules they studied with the researcher in 2006 / 2007 – one in which virtualisation was not used, and one in which it was.

Year	Module	Number of Respondents	Quality of Lab Facilities (1 is lowest rating, 4 is highest)			
			1	2	3	4
2006 / 2007	Practical Networking	17	2	5	8	2
2006 / 2007	Operating Systems	19	-	4	12	3

Table 2 – Student Ratings of the Quality of Laboratory Facilities:
No Virtualisation used in *Practical Networking*;
some Virtualisation used in *Operating Systems*.

As before, it is acknowledged that the relatively small sample size may not be representative of the larger population and that many other variables also need to be considered. However, the authors posit that this data again suggests that educational design interventions using virtualisation technologies may benefit, indeed scaffold, the learning environment. This was the real focus of the study described herein; not to attempt to quantify or measure the impact of this initial intervention, but rather to collect some locally contextual qualitative data that may influence future instructional design using virtualisation technologies, within our own institution as well as elsewhere.

Accordingly, the narrative feedback from the various groups of their experiences with the technology was of much interest. Each of the nine groups submitted a feedback document, typically of 2 – 3 pages in length. As noted earlier, the scope of this feedback element was left deliberately broad so as not to overtly direct student's "insights" and the subsequent documenting of it. This did not always produce the results expected however – the researchers envisioned that students would reflect openly and at length on their learning experiences, and that they would do so with due consideration to the many dimensions of what learning is.

In reality, most groups were quite literal and one-dimensional in their narrative. Having read the requirement (*…was the whole exercise useful, what did you learn, has it helped your understanding of operating systems (and how?), etc…)*, the groups tended to write about what they did and how they did it (down to the level of mouse clicks and menu choices in some cases). Their assessment of their own learning (as articulated in these feedback documents) is largely in terms of what they did or can now do with VMWare, the virtualisation tool they used. The researchers had anticipated, perhaps too ambitiously, that these feedback reports would have produced deeper, more reflective pieces. It may well be that the scope of this particular requirement was too broad to the degree that it was in reality ill structured and vague. It may also be the case that with these particular students, an open-ended self-directed specification such as the one provided is not the best method for gaining insights into learning. In hindsight, perhaps an interview or some type of observational instrument would have yielded better data. There were however a number of comments among the pieces that offer some insight into student learning and what motivates them in the classroom – these comments are in turn a source of motivation to the researchers. One student, for instance, noted: "*overall I found this to be one of the more interesting things I've done at collage (sic). I liked the practical aspect of it and I found it easier to put more time in to it because it did interest me*." A submission from a group of students stated: *"we felt the fact that we worked as a group was highly beneficial as it reduced the individual workloads and allowed us to concentrate on the areas we were good at and improve on other areas with the assistance of our colleagues"*.

RESEARCHERS REFLECTIONS ON THE STUDY

It is our hope that this learning design intervention, described above, was of benefit to our students. Their feedback and performance suggests that it was not detrimental to their learning. We undertook this study and 'embraced' virtualisation in an effort to try and move from the sterile environment of overly scaffolded laboratory sessions (*i.e.* where the learning outcome is almost contrived in advance, and arrived at via a set of instructor provided props or scaffolds). As teachers within the higher education system, the completion of this study has provided us with much to reflect on. In particular, we find ourselves considering the work of Kapur and his notion of productive failure [10] within the context of our practices. Kapur suggests that there is a latent productivity in failure; that failure can be a stepping-stone to success. He further suggests that too much 'scaffolding' of student learning, while possibly efficient in the short term, is to the detriment of flexibility, adaptability and innovation in the long term [10]. Kapur builds this argument via a study of two student groups; one group worked on well-structured scaffolded problems, the other group worked on ill-structured

mmeybodi@aut.ac.ir

unscaffolded problems. A post-test study revealed that the group that worked on the ill-structured unscaffolded problems (at which they mostly failed), showed a better transfer of problem analysis and problem solving skills long term. This argument is supported by Kaufmanns 'law of self-organisation and complexity' [18] which states that in any sufficiently complex system, optimum compromises on the continuum between complete order (scaffolded learning?) and complete chaos (unscaffolded learning?) are made on the *edge of chaos*. We wonder to what extent does virtualisation technology allow a teaching and learning experience to reside at the edge of chaos *i.e.* at the optimum compromise? We witnessed the (virtual) chaos that ensued when a student deleted his fixed disk partition, followed by the relative order that returned because this disaster had happened on a virtual device.

Importantly too, Kapurs work implies that scaffolding is not necessarily the only option – the possibility of learner scaffolding and productive failure can co-exist. Upon further reflection, we see the potential for this co-existence in something as simple as the 'snapshot' feature of the VMWare virtualisation tool. The snapshot feature of the tool allows the user / student / researcher to take a snapshot image of the machine at a point in time. The user can then proceed to a new task (*e.g.* a detailed re-configuration of the machine), at which he may fail. A previous snapshot can easily be reloaded. As such, a 'restart' from a known good point is provided (a scaffold for the learner) such that the lessons learned in the earlier failure can be considered in the next iteration of the task. Failure may result again at the next iteration, the hope would be that such failure would be productive, and as was the case with Kapurs students, lead to improved problem analysis and problem solving skills long term.

Summary and conclusion

The objective of this paper was to share the authors experiences of an educational design intervention that employed virtualisation technologies in the teaching of *operating systems* to a 3rd year undergraduate business computing class. An assignment, centred on the construction of a number of interconnected virtual machines, and supported by instructor facilitated laboratory sessions, was the approach taken. Data collected from current and previous end-of-module surveys was presented along with feedback /comments from students who participated in the virtualisation workshops. The data sets, though small in size and consequently inconclusive from a quantitative perspective, suggest that further research into the use of virtualisation technologies within computer science in higher education is warranted, particularly with respect to scaffolded productive failure. This will be the focus of our future design interventions and research studies.

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mmeybodi@aut.ac.ir

Taxonomy of Linux Kernel Vulnerability Solutions

Serguei A. Mokhov, Marc-André Laverdière, and Djamel Benredjem

Computer Security Laboratory
Concordia Institute for
Information Systems Engineering
Concordia University
Montreal, Quebec, Canada Montreal
Email: mokhov@ciise.concordia.ca, ma_laver@ciise.concordia.ca, d_benred@ciise.concordia.ca

Abstract — **This paper presents the results of a case study on software vulnerability solutions in the Linux kernel. Our major contribution is the introduction of a classification of methods used to solve vulnerabilities. Our research shows that error handling, redesign, and precondition validation are the most used methods in solving vulnerabilities in the Linux kernel. This contribution is accompanied with statistics on the occurrence of the different types of vulnerabilities and their solutions that we observed during our case study, combined with example source code patches. We also combine our findings with existing programming guidelines to create the first security-oriented coding guidelines for the Linux kernel.**

Index Terms — **Linux kernel, Software Vulnerabilities, Vulnerability Remedial, Vulnerability Solutions Taxonomy**

I. Motivation

Linux solutions for both servers and desktops are increasing in popularity and notably so in the developing world as well as virtualization. Today, systems running on the Linux operating system kernel represent 12.7% of server marker and estimated 3%-6% of desktop systems [10], [31]. As Linux is becoming an important actor in the computing world, its security becomes paramount. Similarly to other Unix and Unix-like systems, there is a wide variety of software (desktops, shells, services, etc.) that can be chosen by the administrator from various vendors and the security of a Linux-based system thus relies on the security of a wide set of applications, libraries, programming languages, etc. However, what is unique to a Linux system is the Linux kernel itself. Since the kernel handles file and network operations, access control, resource allocation, etc., its correct functioning is an important part of the overall system security.

We performed this case study on the Linux kernel due to its open-source nature, its popularity, and its development model. This popularity has created a greater interest in scrutinizing the source code for potential vulnerabilities, yielding substantial amount of vulnerability reports to work from. Our study examined the solutions to the vulnerabilities reported in 290 CVE (Common Vulnerabilities and Exposures referred to from [20]) advisories, in the 2.4.x and 2.6.x version families. From these solutions, we drew a classification scheme and computed statistics related to the usage of these families of solutions.

Our major contribution is the classification of the security solutions used for the improvement of the Linux kernel, and C programs in general, as well as statistics on their relative importance. We also introduce a new methodology to track the patch solving a security issue based only on the contents of the security advisory.

The paper is organized as follows: we examine previous work that was done regarding Linux and C security in Section II, followed by a description of the methodology used in order to obtain the solutions to the vulnerabilities in Section III. Afterwards, in Section IV, we show our results, notably classification of the vulnerability solutions we define, as well as statistics related to the occurrence of certain vulnerabilities and their solutions in our data set. In Section V, we illustrate the vulnerability solutions with patches from our data set. In Section VI, we introduce our guidelines for Linux kernel development based on our findings. Finally, in Section VII, we conclude.

II. Related Work

The security of Linux has been covered at many levels in the IT industry. The level that drew the more ink so far has been related to administrative tasks. For example, [11], [18] describe the security features of Linux as well as how to properly configure Linux-based systems. Other works approach the security of Linux systems from the viewpoint of the programmer. For example, Wheeler [32] explains proper coding practices in both generic and language-specific cases. Furthermore, some studies on the security of the Linux kernel done in the past incorporated useful statistics on the preponderance of certain types of software vulnerabilities [5], [24], [33]. The world of software vulnerabilities in C and C++ has been extensively studied [25], [13], [32], etc. This literature will often list various forms of software vulnerabilities, explain, and illustrate them. They will also often propose a method that can be used to remediate the vulnerability. When turning to coding guidelines or code review guidelines [26], [28], [19], [29], [1], [16], we see a need for simple and relevant documentation. In some cases, we can find literature [11], [15] that will describe how we can attack Linux systems as well as countermeasures to such attacks. The open-source community created some high-security variants of Linux for environments requiring it. A first example is the Linux Security Modules

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 485–493.
© Springer Science+Business Media B.V. 2008

mmeybodi@aut.ac.ir

architecture [34], especially known for SELinux [27], which implements strong security policies, and LIDS [14], which offers intrusion detection capabilities. Another option available is Owl [22], a distribution that ensures that the software included runs with minimal privileges and fail-safe defaults which also offers a modified version of the kernel.

However, as far as we know, there is no study that was done on the techniques practically used by developers to remedy Linux kernel vulnerabilities and their relative importance.

III. Approach

In this section we summarize the methods we used to find the remedial methods for given vulnerabilities. Over the course of roughly two years as a part of the research course work, master's research work [23], and general interest we gathered the statistics of common vulnerability solutions, taxonomy of which we present in this paper, covering most Linux kernel vulnerabilities from 2002 to 2007.

We used a spreadsheet program[1] to keep track of vulnerability numbers, version(s) of the Linux kernel, the classification of the vulnerability, links to the solutions, notes on the methodology used to obtain the solution, solution summaries, and the vulnerability solutions' classification in the comma-separated values (CSV) format. This spreadsheet was then processed using a Perl script which generated the statistical information for the counts, tables, and the relevant graphs.

We will now look in more depth at the methodology used to obtain our results. We first chose a reliable data source for Linux software vulnerabilities and extracted relevant vulnerability reports, then used the vulnerability reports as a starting point to find the patch associated. In parallel and after this last activity, we established a classification of the solution types we observed and assigned one or more classification to each of the patches found. We finally developed an automated tool that extracted statistics from the data set we were using.

For the extraction of relevant vulnerabilities, we decided to use the National Vulnerability Database (NVD) [4], [20] for a list of vulnerabilities for its official nature, its comprehensive contents and integrated statistics capabilities [21]. We extracted all the unique vulnerability numbers (the older style of CAN – YYYY – NNNN and the current style of CVE – YYYY – NNNN) for all 2.4 and 2.6 Linux kernel versions using the NVD web interface. This gave us a relatively shortlist of 290 advisories to investigate between years 2002 and 2007.

The second step of our research was to track the precise patch that solved each vulnerability. This task was non-trivial, as no comprehensive database kept track of this information and that the Linux kernel bug-tracking system contained no version 2.4 information and would rarely return any results on CAN/CVE numbers. Thus, we needed to resort to other methods to find patches we were seeking.

We tried to use, as much as possible, the information that was provided directly in the advisory. Often, it included a link to the revision control systems (BitKeeper [2] and GIT [35]), giving us directly the patch related to the problem. Sometimes, the advisory would lead us to Linux vendors' advisories and bug tracking systems that lead to a patch addressing the vulnerability. The advisories would also refer to Bugtraq [3] emails that announced the vulnerability, which sometimes included a patch to the vulnerability. At other times, the best information that we could find from the advisory was the function name, source code file or driver affected, as well as the vulnerable versions. This allowed us to search the patch of the first unaffected version for this precise information and find the solution to the security issue.

We also found that the vulnerability number, expressed under the CAN/CVE schemes, could often be found in vendors' bug tracking systems, maintainer mailing lists, maintainers' management systems [7], enthusiasts' websites [12] and newsgroups [6]. This information often leads us, directly or indirectly, to the patch for the given vulnerability.

The Linux kernel project, for each version, includes a `ChangeLog`. The changelog sometimes would include the CVE/CAN number, or have a comment that allowed us to conclude that it was related to the vulnerability investigated. The commit comment or GIT commit number was then queried for in the BitKeeper [2] archives.

As we were finding the vulnerability solutions, we also examined them and noted a summary of the code changes we observed. Broad categories quickly emerged as we were doing this activity, which we started allocating to solutions that were matching said categories. In order to ensure reasonable consistency and proper classification, the authors refined the classification and each category's definition, and then collectively re-examined most of the patches to ensure that they were correctly classified. Afterwards, we used the earlier mentioned Perl script in order to regroup and count the occurrences of each vulnerability and solution and generate all the statistical figures and table present in the paper.

IV. Results

In this section, we first summarize some information about the nature of the vulnerabilities examined, then proceed to describe our classification, to finally offer some statistics we drew from our vulnerability solutions data.

A. Vulnerability Classification

We used the classification directly from CERT [4], which was included in every vulnerability report. Most of the categories were defined in [5], which we took the freedom of citing and expanding as follows:

Input Validation Error – "failure to recognize syntactically incorrect input" from the interactive user or from a module, process, or function. This category includes subcategories such as buffer overflows and boundary condition errors; however, due to a large number of vulnerabilities in these two subcategories, we mention them separately.

Buffer Overflow – failure to ensure that a computation does not write information outside the intended address space.

Boundary Condition Error – failure to ensure that the acceptable domain or range of data is respected.

Access Validation Error – allowance of "an operation on an

[1]Eventually we hope to migrate to a more flexible and accessible form to manage this database and possible to make it available on-line.

mmeybodi@aut.ac.ir

object outside its access domain."

Exceptional Condition Handling Error – "system failure to handle an exceptional condition generated by a functional module, device, or user input."

Environmental Error – "an interaction in a specific environment between functionally correct modules."

Configuration Error – "a system utility installed with incorrect setup parameters."

Race Condition – "an error during a timing window between two operations."

Design Error – improper design of the security mechanism or implementation not satisfying the design.

Nonstandard – errors not matching any other description or "unknown" errors per CERT.

TABLE I
VULNERABILITY TYPE DISTRIBUTION

Vulnerability Types	Count	%
Design Error	91	28.35
Input Validation Error	55	17.13
Exceptional Condition Handling Error	37	11.53
Buffer Overflow	30	9.35
Boundary Condition Error	29	9.03
Race Condition	25	7.79
Access Validation Error	18	5.61
Nonstandard	15	4.67
Not classified	11	3.43
Environmental Error	6	1.87
Configuration Error	4	1.25
Total	321	100.00

B. Remedial Classification

While gathering and observing our data, we established 13 categories of solutions that were used by Linux kernel maintainers, which classify, define, and illustrate as follows:

Change of Data Types refers to the use of more appropriate data types (such as unsigned instead of signed) or non-static when necessary.

Precondition Validation refers to ensuring that an operation's set of preconditions are met before proceeding with its execution. This is typically done by checking for a valid variable values and range and returning an error code if the conditions are not met. Additionally, this may include the improvement of an existing precondition check, for example by correcting an existing boundary, or adding a missing upper/lower one.

Ensuring Atomicity refers to code modifications that guarantee non-concurrent execution of critical sections, typically by adding locks, semaphores, etc.

Error Handling adds or improves the verification and handling of error conditions. This is typically done by checking the return value of a function call or adding statements in previously existing error handling code. Please note that error handling is most easily distinguished from precondition validation by the fact that it typically occurs within the body of the function, whereas precondition validation occurs at the beginning of a function.

TABLE II
VULNERABILITY SOLUTION DISTRIBUTION

Remedial Types	Count	%
Precondition Validation	83	24.48
Error Handling	62	18.29
Redesign	61	17.99
Fail-Safe Default Initialization	26	7.67
Other	22	6.49
Change of Data Types	16	4.72
Zeroing Memory	15	4.42
Ensuring Atomicity	14	4.13
Input Validation	12	3.54
Protection Domain Enforcement	10	2.95
Capability Validation	8	2.36
Freeing Resources	6	1.77
Unresolved	4	1.18
Total	339	100.00

Zeroing Memory is about ensuring that selected memory contents are overwritten by filling zero values.

Freeing Resources guarantees that resources such as memory and timers are being freed after usage.

Input Validation is the practice of validating or modifying input data in order to ensure it complies with a safety policy.

Capability Validation allows the execution of an operation only after a successful access control check.

Fail-Safe Default Initialization is the setting of a guaranteed safe value for variables before an operation requiring its use. This includes the assignment of a default value at declaration time and ensuring null-termination of strings.

Protection Domain Enforcement guarantees that the data operated on, or the execution flow, is in the appropriate security domain. For example, the programmer can change a kernel reference to a buffer in the user space, which is unsafe, to a copy into the kernel space.

Redesign is often significant code changes, from refactoring to the change of a provider package, including the introduction of new or modification of the existing APIs.

Other solution that could not fit elsewhere in our classification and that was not observed enough (twice or less) to deduce a category. It includes adding function pointers in function tables, changing a buffer size, safe casting, safer pointer arithmetic, error reporting, loop termination, low-level assembly corrections, etc.

Unresolved are flaws to which a solution was not available yet at the time when the statistics was gathered.

C. Statistical Analysis

Of the 321 vulnerabilities to date[2] we found 339 solutions. We saw that design error, exceptional condition handling error, and buffer overflow were dominating the errors at the root of the vulnerability advisories (Table I). A corresponding diagram is in Figure 1.

[2] End of November 2007.

mmeybodi@aut.ac.ir

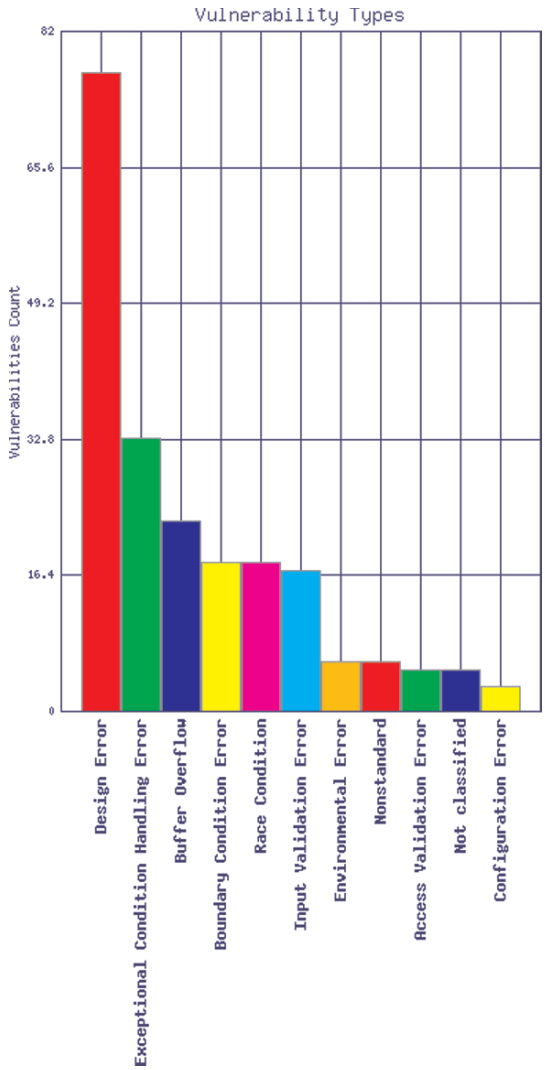


Fig. 1: Sorted Vulnerability Types Observed

In our analysis, we observed that error handling, redesign, and precondition validation were dominating the solutions (see Table II and the corresponding diagram in Figure 2). The numbers purposefully do not match the number of advisories evaluated (here 290 CVEs), as one advisory can contain multiple vulnerabilities, each potentially showing multiple methods used together to remedy it.

The additional statistics in Figure 3 lists counts of number of vulnerabilities in the kernel for 2.4, then for 2.6, and vulnerabilities that spanned across both branches.

V. Example Patches

In this section, we illustrate each remedial method via a patch. The patch file format is a standard way to represent changes between two versions of the file [17].

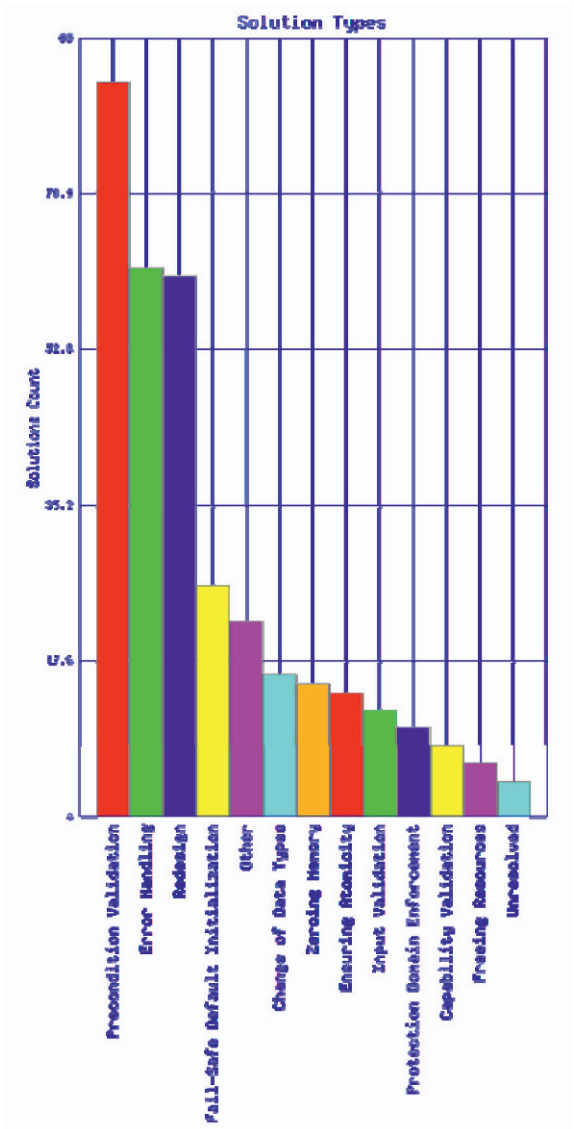


Fig. 2: Sorted Solution Types

A. Change of Data Types

In many cases, the data type used was not appropriate for the data representation needed or the concurrency scenario. Typically, the change is from signed to unsigned types, or from static to non-static. The Listing 1 shows how a vulnerability was remedied by making a variable non-static, avoiding its sharing between threads.

B. Safe Casting

Some casting operations, such as integer promotions, are generated automatically by the compiler. In some cases, the casting can be inappropriate, especially when working on legacy code for new 64-bit platforms. The maintainer must sometimes add explicit casts and variables of the appropriate

mmeybodi@aut.ac.ir

type in order to ensure that the data will be of the appropriate form. The listing 2 shows how a vulnerability was remedied by using a reference to the desired value of a safe data type, instead of relying on the compiler to correctly cast the pointer dereference.

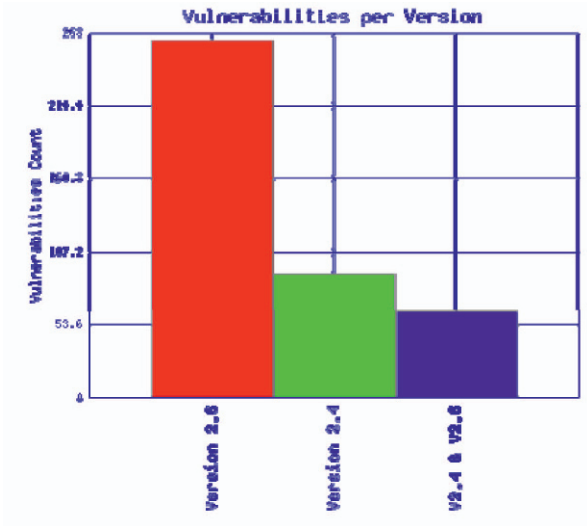


Fig. 3: Number of Vulnerabilities Found Per Kernel Branch

C. Precondition Validation

Any function typically has a few implicit and/or explicit preconditions for its proper operation. These preconditions are not always validated, leaving room for potential vulnerabilities. A programmer must thus make those preconditions explicit and ensure that they are validated before the function's body is executed. The Listing 3 shows how a vulnerability was remedied by ensuring the validity of the `len` parameter.

```
{
  enum ip_nat_manip_type maniptype,
  const struct ip_conntrack *conntrack)
  {
-     static u_int16_t port, *portptr;
+     static u_int16_t port;
+     u_int16_t *portptr;
      unsigned int range_size, min, i;

      if (maniptype == IP_NAT_MANIP_SRC)
  }
}
```

Listing 1. Example of Change of Data Type by Removing Static Assignment for CVE – 2005 – 3275

D. Ensuring Atomicity

Some code must be inherently thread-safe, because of the nature of operating systems requiring concurrent execution of certain functions. As such, a maintainer must ensure proper locking of critical sections before executing them (or merely obtaining a reference to sensitive data structures), as well as ensuring the proper management of timers when some are involved. The Listing 4 shows how a vulnerability can be remedied by ensuring the locking of a data structure before manipulating it through a pointer.

```
    if (!state->pri_unat_loc)
      state->pri_unat_loc = &state->sw->ar_unat;
    /* register off. is a multiple of 8, so the
        least 3 bits (type) are 0 */
-   s[dst+1] = (*state->pri_unat_loc - s[dst]) |
    UNW_NAT_MEMSTK;
+   s[dst+1] = ((unsigned long) state->pri_unat_loc
    - s[dst]) | UNW_NAT_MEMSTK;
    break;

    case UNW_INSN_SETNAT_TYPE:
```

Listing 2. Example of Safe Casting Remedial to CVE – 2004 – 0447

E. Error Handling

In many cases, the error status of some functions is not checked, or the handling of the error is not appropriate in context. Programmers must thus ensure that the good coding practice of validating all function return values, as well as the error handling schemes and other error conditions specific to the context. The Listing 5 shows how an error condition requires the freeing of memory and the communication of an error status to the caller.

```
      if (!len)
          return addr;

+     if ((addr + len) > TASK_SIZE || (addr + len) <
    addr)
+         return -EINVAL;
```

Listing 3. Example of Improved Precondition Validation for CVE – 2004 – 0003

F. Zeroing Memory

Some sensitive information can be left in the memory from previous kernel operations, allowing possible private data leaks. A maintainer should preventively ensure that memory contents are wiped before using in the context where it can be read by a user process, normally by filling the memory segment with zero values. The Listing 6 shows how a disclosure vulnerability was solved by a few calls to `memset`.

```
  struct ebt_chainstack *cs;
  struct ebt_entries *chaininfo;
  char *base;
- struct ebt_table_info *private = table->private;
+ struct ebt_table_info *private;

  read_lock_bh(&table->lock);
+ private = table->private;
  cb_base = COUNTER_BASE(private->counters, private
      ->nentries, cpu_number_map(smp_processor_id())
      );
  if (private->chainstack)
```

Listing 4. Example of Atomicity Guarantee for CVE – 2005 – 3110

G. Freeing Resources

Some security vulnerabilities can occur due to memory leaks or unreleased resources such as timers. A maintainer must ensure that good programming practices regarding resource management are enforced. Listing 7 shows how a denial of service condition was remedied by removing memory leaks.

H. Input Validation

Input validation consists of validating or modifying input data in order to ensure it complies with a safety policy by either truncation or filtering. A maintainer should ensure that all data

mmeybodi@aut.ac.ir

going through a security boundary, notably all data coming directly from a user, is validated for correctness. The Listing 8 shows how input validation capabilities were not fully used for a bridge forwarding functions, allowing a vulnerability, and how it was simply solved by ensuring a specific subset of traffic for filtering.

```
int syscall32_setup_pages(struct linux_b
int npages = (VSYSCALL32_END - VSYSCALL32_BASE) >>
    PAGE_SHIFT;
struct vm_area_struct *vma;
struct mm_struct *mm = current->mm;
+ int ret;
  vma = kmem_cache_alloc(vm_area_cachep, SLAB_KERNEL
      );
  if (!vma)
@@ -78,7 +79,11 @@ int syscall32_setup_pages(struct
    linux_b
  vma->vm_mm = mm;
  down_write(&mm->mmap_sem);
- insert_vm_struct(mm, vma);
+ if ((ret = insert_vm_struct(mm, vma))) {
+   up_write(&mm->mmap_sem);
+   kmem_cache_free(vm_area_cachep, vma);
+   return ret;
+ }
  mm->total_vm += npages;
  up_write(&mm->mmap_sem);
  return 0;
```

Listing 5. Example of Improved Error Handling for CVE – 2005 – 2617

I. Capability Validation

In some cases, it is necessary to validate the executing principal's rights in an access control matrix. This is a special case of precondition validation which we considered worthy to mention separately. The Listing 9 shows how a simple check remedies a security vulnerability.

```
    goto fail;
  }
  kaddr = kmap_atomic(page, KM_USER0);
+ memset(kaddr, 0, chunk_size);
  de = (struct ext2_dir_entry_2 *)kaddr;
  de->name_len = 1;
  de->rec_len = cpu_to_le16(EXT2_DIR_REC_LEN(1));
```

Listing 6. Example of Zeroing Memory to Solve Data Leaks in CVE – 2004 – 0685

J. Fail-Safe Default Initialization

Relying on default initialization performed by the compiler can be tricky at best, especially when a simple compile option can disable the feature overall (see, for example, the relevant options like `-Wuninitialized` and `-Wmissing-field-initializers` in GCC[36]). Furthermore, the default initialization may not be to a value that we need for our context. As such, maintainers should ensure that critical variables are assigned to known safe values, or that strings are guaranteed to be zero-terminated. Listing 10 shows how setting a pointer to NULL remedied a denial of service vulnerability.

```
    kenter("{%d}", key->serial);

    key_put(rka->target_key);
+   kfree(rka);

 } /* end request_key_auth_destroy() */
```

Listing 7. Example of Remediation of Memory Leaks for CVE – 2005 – 3119

```
  struct net_bridge *br = p->br;
  unsigned char *buf;

+ /* insert into forwarding database after filtering
     to avoid spoofing */
+ br_fdb_update(p->br, p, eth_hdr(skb)->h_source);
+
  /* need at least the 802 and STP headers */
  if (!pskb_may_pull(skb, sizeof(header)+1) ||
      memcmp(skb->data, header, sizeof(header)))
```

Listing 8. Example of Improved Input Validation Remediating CVE – 2005 – 3272

K. Protection Domain Enforcement

In the case of the Linux kernel, the data operated on can be either in user space or in kernel space. The kernel implements this differentiation by copying data between kernel and user space as needed, hereby ensuring that the information is not altered during an operation. Listing 11 shows an example of this, where the call `copy_to_user` was added with error handling.

```
do_kdgkb_ioctl(int cmd, struct kbsentry
  int i, j, k;
  int ret;

+ if (!capable(CAP_SYS_TTY_CONFIG))
+   return -EPERM;
+
  kbs = kmalloc(sizeof(*kbs), GFP_KERNEL);
  if (!kbs) {
    ret = -ENOMEM;
```

Listing 9. Example of Capability Validation Solving CVE – 2005 – 3257

L. Redesign

The option to redesign often requires major code changes, as functions are added or removed (or have their signatures changed), that new options appear or disappear, etc. A maintainer can improve the security of a system by changing a weak module by another which is safer (and adjusting interfaces if necessary), remove some dangerous options, etc. The Listing 12 shows how a dangerous option needed to be removed from the code.

```
  size_t array_size;

  /* set an arbitrary limit to prevent arithmetic
      overflow */
- if (size > MAX_DIRECTIO_SIZE)
+ if (size > MAX_DIRECTIO_SIZE) {
+   *pages = NULL;
    return -EFBIG;
+ }

  page_count = (user_addr + size + PAGE_SIZE - 1) >>
       PAGE_SHIFT;
  page_count -= user_addr >> PAGE_SHIFT;
```

Listing 10. Example of Fail-Safe Default Initialization Remediating CVE – 2005 – 0207

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```
case VIDIOCSWIN:
{
-  struct video_window *vw = (struct video_window *)
     arg;
-  DBG("VIDIOCSWIN %d x %d\n", vw->width, vw->height
    );
+  struct video_window vw;

-  if ( vw->width != 320 || vw->height != 240 )
+  if (copy_from_user(&vw, arg, sizeof(vw)))
+    {
       retval = -EFAULT;
+      break;
+    }
+
+  DBG("VIDIOCSWIN %d x %d\n", vw->width, vw->height
    );

+  if ( vw.width != 320 || vw.height != 240 )
+    retval = -EFAULT;
     break;
   }
```

Listing 11. Example of Protection Domain Enforcement Remediating CVE – 2004 – 0075

M. Other

Other methods were not encountered in a frequency allowing us to classify them into category for themselves. Thus, the "Other" category of improvements. The Listing 13 shows a vulnerability solved by changing default file permissions.

```
- sctp_lock_sock(sk);
-
- switch (optname) {
- case SCTP_SOCKOPT_DEBUG_NAME:
- /* BUG! we don't ever seem to free this memory. --
    jgrimm */
- if (NULL == (tmp = kmalloc(optlen + 1, GFP_KERNEL)
    )) {
-   retval = -ENOMEM;
-   goto out_unlock;
- }
-
- if (copy_from_user(tmp, optval, optlen)){
-   retval = -EFAULT;
-   goto out_unlock;
- }
- tmp[optlen] = '\000';
- sctp_sk(sk)->ep->debug_name = tmp;
- break;
+ sctp_lock_sock(sk);

+ switch (optname) {
  case SCTP_SOCKOPT_BINDX_ADD:
```

Listing 12. Example of Redesign by Removal of Option for CVE – 2004 – 2013

```
 MODULE_PARM_DESC(debug, "Enable debug output");

 module_param_named(cards_limit, drm_cards_limit,
     int, 0444);
-module_param_named(debug, drm_debug, int, 0666);
+module_param_named(debug, drm_debug, int, 0600);

 drm_head_t **drm_heads;
 struct drm_sysfs_class *drm_class;
```

Listing 13. Example of Other Solution: Changing Default File Permissions for CVE – 2005 – 3179

VI. Secure System Software Coding Guidelines

We are going to use the knowledge acquired in this study in order to summarize and improve existing secure coding checklists and guidelines [1], [13], [29], [16], [25], [26], [28], [32], [19] and apply them to kernel and system software development. Although those guidelines will overlap greatly with existing guidelines and common programmer knowledge, this contribution remains the first set of general guidelines for Linux kernel development specifically.

A. System Software Design Guidelines

A wide spectrum of errors is classified as design errors. The solutions here range over different aspects of validation, error handling, and redesign. Therefore, it is difficult to provide a checklist in this category other than suggest more formal approach to the system software development process with requirements, design, and extensive unit and acceptance testing versus just mere code hacking. Every module shall have its security requirements listed and documented and every patch to that module has to be always checked against those requirements prior application. A good example of a *failure* to do so is a replacement of a broken `cryptoloop` implementation with another, similarly broken package (see CVE-2004-2135 and CVE-2004-2136). Additionally, the coding conventions that exist as well as mandatory comments for non-trivial pieces of code should be enforced. Linus Torvalds provided such guidelines for Linux [29], but there still a lot of code that disobey them or is undocumented. It would be advisable for the developer community to gradually and systematically re-read and re-document each module/unit as it is being maintained combined with automated documentation generators (such as Doxygen [30]).

Finally, it is beneficial to maintain unit tests for all modules. One typical organization is having a separate tree hierarchy mimicking the original source code tree to include the unit tests. Another organization is to have the tests in the same hierarchy, but using a naming convention allowing to easily distinguish the tests from the implementation. Integration and regression testing helps the system at large to avoid situation where a small change in one module triggers a large failure somewhere else while not surfacing right away to the developers.

B. General Code Guidelines

As we have seen, the vast majority of errors simply come from the lack of validation of input, parameters, and return values that go in and out to functions through parameters or environment. Thus, at all cases an error handling of return values from system calls and alike must be performed (see Listing 5), a check and sanitization of all input arguments (see Listing 8) and environment variables for validity prior use, proper initialization to trusted values (such as in Listing 10) and so on. These guidelines seem obvious, but surprising even at the kernel level are not always followed, where it is a must.

Next, we need to consider termination conditions (e.g. loop termination) as well as code reachability. In some cases, loop termination conditions need to be added to ensure that a loop terminates after a finite number of iterations. One form of never-ending loops is seen in infinite recursion, which should be guarded against. Finally, we need to ensure that all paths of

mmeybodi@aut.ac.ir

the code are reachable (something that can be ignored, as show in Listing 13).

Further, there are many boundary errors related to signness or data type size errors. Expected signness should always be documented for every function or variable and conversion macros to check and convert types from signed and unsigned should be used to avoid or detect integer overflows and the like. Unsigned variables should be used instead of signed ones whenever possible.

Additionally, unit testing can catch a lot of such errors, and static analysis tools [8], [9], [24] can be an useful complements. Ultimately, one of the most useful tools remains self and peer review.

C. Privileged Code Guidelines

The privileged code should be kept as short as possible [19]. Such code typically raises privileges to perform certain task (e.g. I/O) and then has to drop the privileges right after according to the least privilege principle. In the kernel, such code paths are typically in the device drivers. The danger here is that often the privileged code executes on behalf of untrusted user-level application (e.g. via system calls to read/write files or spawn processes), and as such has access to many system resources the application would not. Thus, if an application could circumvent the system code while in privileged mode, it could gain unauthorized access. Therefore, the time window where the privileges are raised, should be as short as possible.

Furthermore, it is essential that the data operated on be a copy of the data supplied by the user, and not a reference to it, as this could allow a malicious user to transform it during the processing (as illustrated in Listing 11). Finally, privileged operations need to filter input in order to avoid exploitation and increase of privilege through tainted variables.

D. Concurrent/Parallel Code Guidelines

System software, such as an operating system, should always be developed with concurrency in mind. The improper coding typically results in race conditions. The race conditions are possible where there is a more than one execution context (of a process or a thread) is attempting to access a shared resource (e.g. device, variable or a data structure, as illustrated by Listing 1). Thus, whenever dealing with global/static variables or states, acquiring proper locks or semaphores prior entry to a critical section of code and releasing them right after leaving it should be maintained. The use of static variables in functions should be avoided (or at least carefully analyzed) and local variables referring to a lockable data structure or part thereof should be initialized only after the lock has been obtained (see Listing 4). The critical section code in the code, just like privileged section code, should be as small as possible to avoid lock contention and slowdown (due to serialization of concurrency). The critical section code must be small and thoroughly documented with expected execution scenarios to increase confidence that it is deadlock-and starvation-free. For this task some formal methods can be used, deadlock avoidance, detection, or preemption algorithms should be implemented. The latter, however, typically degrade system performance, but could be enabled as part of the debug mode.

Another way to improve concurrency and reduce locking overhead is to use copies of kernel data structures or make them immutable where possible throughout the code as no locking or mutexes are needed for immutable or copied data structures.

E. Performance Coding Guidelines

While coding for performance is a noble goal, it has to be justified in some cases as overly-optimized code can lower maintainability and be prone to security bugs. In general, it is not acceptable to remove precondition validation and error handling checks for the sake of saving a few CPU cycles.

It is important to remember that many performance issues are better resolved through profiling and proper design. For example, on single-threaded uniprocessor machines, spinlocks relying on busy-waiting should be avoided in favor of sleep-waiting primitives.

In some cases, performance issues related to long recursions become security issues (denial of service). Recursions should be replaced by bounded iterative solutions. Such a solution will increase performance and avoid a security issue.

F. Resource Management Code Guidelines

This category deals with resource leaks as in forgetting to free unused ones as well as privileged information leaks that migrates from kernel memory to user memory. Typically, all explicitly dynamically allocated resources (e.g. memory, timers, file descriptors, etc.) should be freed explicitly. If the allocation and deallocation happen in the same function, then allocation and deallocation statements (e.g. `kalloc()` and `kfree()` or `open()` and `close()`) shall used right away as if they were types of brackets while programming. One example can be seen in Listing 7. When this is not the case, proper documentation is a must, and conversion from raw resource management (allocation/deallocation) to more abstract resource management (i.e. using reference counts) should be considered. When code is reviewed, we need to ensure that the resources are deallocated only once in all code branches, a task particularly suited for static analysis tools.

Another type of erroneous resource management sometimes enables sensitive information leakage by the kernel (as show in Listing 6). This typically occurs when data structures are not zeroed by default.

G. Debug/Log Code Guidelines

Assertions and debug macros are good tools for in-place debugging and shall always be used extensively. They don't result in performance penalty when compiled with the debug macros and assertions disabled. Debug/logging should be useful and traceable to the code for debug and auditing purposes. The debug information should include timestamps, UIDs, PIDs, creation/destruction of processes and files.

mmeybodi@aut.ac.ir

VII. Conclusion

During our case study, we have found that the practices used by the Linux kernel development team to improve the security are the error handling, redesign, precondition validation, fail-safe default initialization, change of data types, ensuring atomicity, zeroing memory, input validation, protection domain enforcement, capability validation, freeing resources, unresolved, and other.

We also computed the relative frequencies of occurrence of each type of vulnerability solution. As our survey found, it is clear that a lot (about 40%) of vulnerabilities were remedied with error handling and precondition validation, which can be easily found and corrected in an audit review. We hope that this conclusion will aid developers of system software to implement proper methodologies and programming guidelines that will prevent many vulnerabilities in the future. The examples and guidelines we offer in this paper could also be furthered for training maintainers in detecting and properly correcting security vulnerabilities.

VIII. Acknowledgments

We would like to thank Dr. Mourad Debbabi for his guidance in assisting with this topic and this paper reaching the publication stage, Dr. Chadi Assi for his efforts in this work as the initial project topic in his Operating Systems Security class and the Linux Kernel Hackers who collaborated with us: Simon 'Horms' Horman, Eric W. Biederman, Nikos Ntarmos, Linus Torvalds, Andrew Morton, Greg K.-H.

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mmeybodi@aut.ac.ir

Competency-based, Customer-Oriented Curriculum Design Methodology: A Case Study

S. Avasilcăi
C. A. Huţu
The Technical University "Gh. Asachi" of Iaşi
Bd. D. Mangeron 53, Iaşi 700050, ROMANIA

Abstract - **The paper presents a competency-based, customer-oriented curriculum design methodology based on the Quality Function Deployment concept. The methodology is presented within the framework of a case study on the development of an international Master's program in Quality Management, aimed at developing professionals capable to adequately perform in highly competitive markets of the global economy. The case study also stresses out the role of e-learning in meeting the educational customers' specific needs.**

I. Introduction

Linking the academic ground with real-life demand is not a new or original concept, but it becomes critical in a global economy and it constitutes a global trend in higher education.

In attempting to meet this overall demand, the paper presents an innovative approach to devise a competency-based, customer-oriented curriculum design methodology based on the Quality Function Deployment (QFD) concept.

QFD refers to the philosophy and adjacent sets of planning and communication tools focusing on customer needs and wants in coordinating the design, manufacturing and marketing of products. Used worldwide as a powerful quality tool, QFD represents a meaningful means of translating customer requirements into the appropriate technical requirements for each stage of product life cycle [1, 2].

Of the four generic planning documents, the "Customer Requirements Planning Matrix" or the "House of Quality" is the basis of QFD. This matrix relates customer requirements or attributes ("the voice of the customer" [3]) with technical features or counterpart characteristics in order to make sure that the product meets the customer needs. In developing a product based on QFD, three major steps are usually followed [4]:

- Identifying customer attributes;
- Identifying counterpart (technical) characteristics;
- Relating the customer attributes with the counterpart characteristics.

Based on the data provided by the House of Quality, real life evaluations of competing products and counterpart characteristics ought to be conducted in the view of setting specific targets.

Combining this generic methodology with the UNIDO competency-based framework [5, 6], the authors attempted to devise a curriculum design methodology within the framework of a case study targeting a particular 'product': an International Master's Program in Quality Management (QM), aiming at promoting excellence in teaching, learning and service for all key constituencies. The case study also stresses out the role of e-learning in meeting the educational customers' specific needs.

II. Identifying Customer Attributes

Customer attributes were identified within the competency-related framework based on market research [7, 8] and the research and experiences of the authors in previous QM programs jointly developed with partners from European Union countries, within the framework of several Tempus and other international projects [9 – 14].

A. Market Research Results

Among the EU projects promoted by the authors in order to develop new learning vehicles for the Romanian higher education system at international standards, the Leonardo da Vinci project, "Technological Toolkit for Entrepreneurs over 40 – TTE@40", provided the wider and most relevant perspective on training needs of professionals conducting businesses across Europe.

The project included educational institutions and NGOs from seven European countries, namely Austria, Spain, France, Romania, The Netherlands, Slovakia and the UK.

In their respective countries, the partners have carried out research on training needs aiming at developing a multimedia training resource for mid-career entrepreneurs in order to enhance their performance in the fields of quality, innovation and technology.

The results were then unified in a European Report.

A jointly designed quantitative survey was carried out using locally defined samples. The decision was made that the partners would define their own samples using their network of contacts. This method is commonly used when trying to contact hard to reach groups.

The sampling decision was also based on the research methods literature [15] which discusses the strengths and weaknesses of different sampling techniques to conduct research into the motivations of business angels. Whilst the various authors acknowledge weaknesses in all approaches, they commonly use the "snowballing" technique which

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 494–498.
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mmeybodi@aut.ac.ir

assumes that business angels will be linked by businesses and social networks.

Our research used a similar approach assuming the organizations involved in the study would have similar networks to access in order to reach a significant number of mid-career entrepreneurs. In some countries (e.g. UK and the Netherlands) this network approach resulted in a high contact rate of targeted participants. In other participant countries it resulted in a high contact rate with former students because universities used alumni databases.

Moreover, all partners triangulated the research by conducting qualitative follow-up through either focus groups or telephone interviews.

The survey contained 60 questions relating their personal background, their proposed or actual businesses, areas where they felt they would liked or needed training, their personal management and IT&C skills as well as four questions relating to future contact and quality control. The surveys were either mailed, e-mailed or a mixture of the two.

The partners also conducted qualitative background research into the business environment in their country. They carried out follow up interviews either by phone or in focus groups to explore in further detail some of their research findings.

The top three areas of priority concerning training and development needs for the Romanian managers and professionals were creativity and innovation, quality, business plan writing skills, global business environment, and sources of finance. These priorities clearly show deep concern of the Romanian managers and professionals in respect with planning and funding their businesses in a very competitive, global business environment that they don't yet understand very well.

At the EU level, the results varied widely from country to country. In the Netherlands and UK the respondents highly rated skills such as time management and selling skills which are needed by the individual entrepreneur. The UK group however, differed in that they were concerned more with the managerial basics of marketing a product and financing a business. The Dutch group focussed more on the individual entrepreneur's skills and put communication, creativity and presentation skills higher.

It is interesting that creativity/innovation came top in both Austria and Romania. The remainder of country responses were pretty uniform in covering the business basics: quality management, marketing, strategy, sources of finance, financial management, advertising, finding customers. The only country where correspondents were concerned about business law was in France, which can be explained by national requirements in this area and the fact that entrepreneurship has declined over the last 30 years.

Overall, respondents were interested in a mixture of technical (marketing, financial, legal, pricing, IT) and entrepreneurial (creativity and innovation, quality, time management, communication, sales, strategy building) competences and skills depending on their stage of start up and their national environment.

The research also encompassed a qualitative research, by means of focus groups, the findings of which reflected national preoccupations. The Dutch participants wanted help in accessing the funding they know is available for new, technology-based start-ups. The Romanian focus group thought they already had most of the knowledge and skills to run a business. With regard to proposed courses they suggested a preparatory IT course might be useful. They also wanted the courses to be low cost, highly flexible and not requiring too much time. The Slovakian focus group showed older people were likely to be IT illiterate and younger people who would be interested faced high costs in accessing the Internet. The Spanish research partner held 2 focus groups. The first was with MBAs who were keen that any computer-based training had a professor behind it to answer student queries and monitor student progress. The second focus group was made up of women entrepreneurs whose training needs were described as being "closer to product commercialization than enterprise management". The UK interviews revealed a preoccupation with funding, its amount, timing and the bureaucracy associated with it. Time constraints were mentioned by several of those running their businesses as potential barriers to accessing further training.

B. The Competency-related Framework

The authors based their approach on the following definitions of competency:

- The integrated knowledge, skills, attitude, and judgment expected of the practitioner [16];
- Can be knowledge, attitudes, skills, values, or personal values;
- Can be acquired through talent, experience, or training;
- Comprises the specification of knowledge and skill and the application of that knowledge and skill to the standard of performance required in employment.

The set of core competencies for the international QM Master's program is presented in Fig. 1, on the basis of the UNIDO competency-related framework [17] and the previous work of the authors [18].

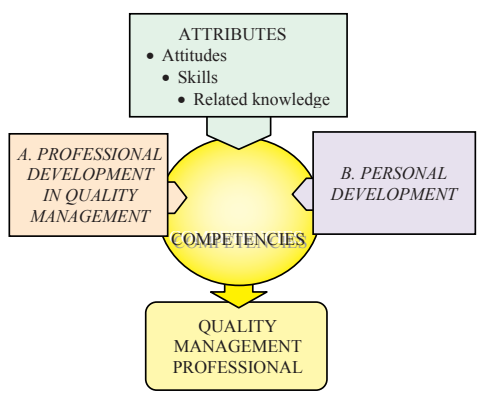


Fig. 1. Core competencies framework for a QM Master's Program

mmeybodi@aut.ac.ir

The two key subsets of core competencies (A. Competencies related to professional development, and B. Competencies related to personal development essential for supporting professional development) generated the following objectives for the program:

- To develop generic theoretical and practical competencies in QM;
- To acquire the knowledge and know-how in QM adequate to proactively act on the demands of competitive business environments;
- To develop the QM competencies adequate to efficiently and effectively manage production and business systems;
- To develop competencies in building strategic partnerships with the business environment and the local, national and international communities in order to facilitate access and success in competing in highly competitive EU/global markets.

C. Customer Attributes Defined

Integrating the market research data with the competency-related framework, the authors defined the 'product' requirements in customer's terms, presented in Table 1.

TABLE I
IDENTIFYING CUSTOMER ATTRIBUTES

Attributes					
Attitudes		Skills		Related Knowledge	
CA-A	Quality "wise"	CA-A1	Quality "aware"	CA-A1.1	Quality "history" / "guru"
				CA-A1.2.	Quality definitions / perspectives: What is quality?
				CA-A1.3.	Quality – "Where in the company?" – strategy, policy, culture, process approach
		CA-A2	Develop, implement and maintain the Quality Management System	CA-A2.1.	Process identification
				CA-A2.2.	Approaches to Quality Management (ISO and others)
				CA-A2.3.	Assessment of company "quality state" (internal and external)
CA-A	Quality "wise"	CA-A2	Develop, implement and maintain the Quality Management System	CA-A2.4.	Quality Management System documentation , implementation and review
		CA-A3	Manage the company's effort to provide improved quality	CA-A3.1.	Tools and techniques for quality improvement
				CA-A3.2.	Excellence models
				CA-A3.3.	Benchmarking
				CA-A3.4.	Quality costs
		CA-A4	People skills / change agent	CA-A4.1.	Motivation, involvement and commitment
				CA-A4.2.	Team approaches (team building, teamwork)
				CA-A4.3.	Ethical behavior
				CA-A4.4.	Conflict resolution
				CA-A4.5.	Performance evaluation and rewarding
CA-B	Develop learning capabilities	CA-B1	Managing information	CA-B1.1.	Info gathering and selection based on IT&C
				CA-B1.2.	Info use: individual, group & organizational, based on IT&C
		CA-B2	Putting knowledge into practice / "action"	CA-B2.1.	Conduct diagnosis

mmeybodi@aut.ac.ir

CA-B	Develop learning capabilities	CA-B2	Putting knowledge into practice / "action"	CA-B2.2.	Conduct organizational interventions
		CA-B3	Presentation skills	CA-B3.1.	Communication: written, oral and non-verbal
CA-C	International 'thrust'	CA-C1	Internationally marketable & valid	CA-C1.1.	International practices
				CA-C1.2.	Manage cross-cultural differences
		CA-C2	Nationally valid	CA-C2.1.	Accredited in Partner countries

III. Identifying Counterpart Characteristics

Following the identified client's needs, the international QM Master's program aims at creating an interactive learning environment through innovative course content and learning methods, based on IT&C.

Two key concepts lay the foundation of this approach [19]:

- *Integration* – high profile guest speakers with class discussions, and with permanent contact and debates using a designated e-learning portal resources; this way, the program creates a complex learning environment though stimulating thought and debates by using in-class and e-debates, team teaching, and international visiting faculty and recognized professionals;
- *Flexibility* – to allow the working international graduate students the time and 'space' to actively and intensively participate in the program; the e-learning platform will be implemented to create the learning environment for enhancing high quality, interactive teaching and learning along with more 'classical' approaches, such as class debates, case studies etc.; also, the customized e-learning platform will provide access to, and download of, course materials (e-textbook, suggested readings, Internet links, etc.), and the use of electronic message interchange, discussion forum, and on-line debate space.

Based on this general framework, counterpart characteristics were identified as following:

CC-A Accessibility
- CC-A1 Entry requirements
- CC-A2 Equal opportunities
- CC-A3 Multilingual

CC-B Hands-on (practice oriented)
- CC-B1 Customization
- CC-B2 Cross-country internships
- CC-B3 Key speakers
- CC-B4 Practical assignment
- CC-B5 Pedagogical tools

CC-C Flexibility
- CC-C1 Modular structure
- CC-C2 Use of transferable credit systems
- CC-C3 Methods of delivery
- CC-C4 Seamless delivery/location flexibility
- CC-C5 Delivered in 3 stages/Certificates

CC-D Cutting-edge program
- CC-D1 Courses content
- CC-D2 Methods of delivery
- CC-D3 Student evaluation
- CC-D4 Course evaluation
- CC-D5 Library
- CC-D6 Equipment
- CC-D7 Facilities
- CC-D8 Partner institutions

CC-E Cost effective
- CC-E1 Resource utilization
- CC-E2 Break-even

IV. The House of Quality

A relationship matrix between the customer attributes and the counterpart characteristics was developed in order to emphasize strong/weak interrelationships between any pair of counterpart characteristics and to show whether the technical characteristics are adequate in relation with customer requirements (Fig. 2.):

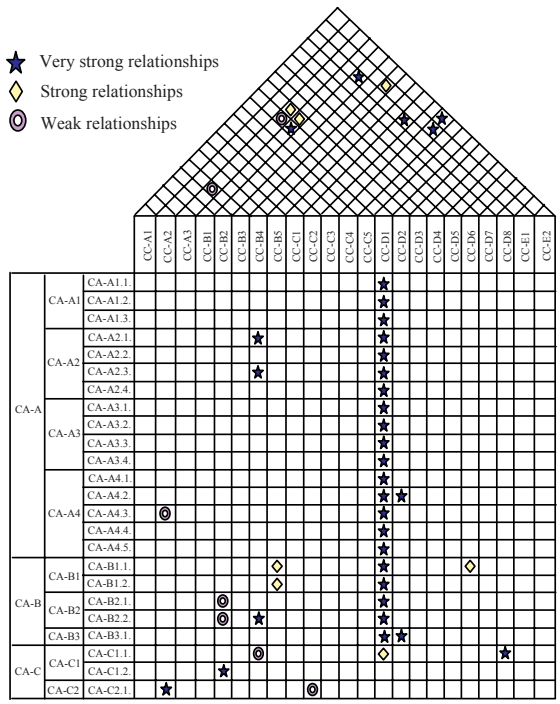


Fig. 2. – The House of Quality

mmeybodi@aut.ac.ir

The use of QFD in designing an educational program was done in a strategic perspective: QFD can be used not only to design the program but also to evaluate the performance of the program, in order to continuously improve the educational offer and to meet and exceed the requirements expressed by the "voice of the customer".

In evaluating the performance of the program the QFD methodology can build upon the Balanced Scorecard Model, a powerful tool for defining and monitoring the performance requirements of all relevant stakeholders.

V. Conclusions

It can be pointed out that the House of Quality created the opportunity to structure the technical characteristics of an International Master's Program around customer needs, setting the stage for further real life developments.

The particular case of the competency-based customer-oriented International QM Master's Program illustrates this curriculum development methodology, aiming at being an innovative, flexible approach at international standards to effectively respond to the real needs of the EU market and the global economy.

The novelty of the Program, characterized by an interdisciplinary approach, innovation in learning and teaching - based on trust, freedom, equality, contribution, commitment, personal and team responsibility etc. -, flexibility and openness to various stakeholders' needs could constitute strong motivators for recruiting top quality international students and faculty.

Based on the strengths and weaknesses underlined by the relationship matrix between the customer attributes and the counterpart characteristics, a first draft of the Master's Program can be developed by a joint team of key representatives from interested higher education institutions.

Following, real life evaluations of the proposed Program, competing 'products' and counterpart characteristics will be conducted in the view of setting specific targets and begin preparation to launch the final 'product' on the market.

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mmeybodi@aut.ac.ir

Using Embedded Systems for Literacy Teaching and Learning

S. Nicola, R. Solea, D. Dobriceanu and R. Tonca
University of Craiova
Faculty of Automation, Computers and Electronics
Blvd. Decebal 107
200440 Craiova, Romania

Abstract—**The application described in this paper consist in an embedded system based on a cost effective thin-client PC (the e-Box) and running a software developed in Windows CE environment, using .NET compact framework and C# as programming language. External hardware used with e-Box is: a graphic tablet as pointing device, a VGA to TV converter for using a standard TV set as display, an USB memory stick and speakers. The application is developed for Romanian language but there is also provided necessary building blocks and interfaces to help other developers extend the platform for their own language and culture.**

I. INTRODUCTION

Illiteracy is still a black hole in modern-day society, with around one billion people all over the world unable to read or write. In advanced societies, illiteracy is closely linked to social exclusion, to shame, social immobility and poverty [1].

As starting point was the Romanian example of Roma people minority, whose illiteracy level is notorious, illiteracy that, among other causes, is feeding a real poverty cycle. The World Bank study [8] states that compared to the estimated national illiteracy rate of 2 to 4 percent (citing Romanian Ministry of Education), 44 percent of Roma men, and 59 percent of Roma women were illiterate. This is also true for other more developed countries. Another example in the same study, referring to Spain states that, even if Spain is EU member for a long time, illiteracy levels for adult Roma are high, with rates approaching 70 percent. For the population over the age of 55, illiteracy rates for men and women are around 75 percent and 90 percent, respectively. In Portugal, almost half of the population can barely read and write. Even in Germany, 14 per cent of the country's population is stated to have severe difficulties with reading and writing [2].

Due to lack of resources and limited knowledge of available technology, adult literacy programs in Romania have only recently begun to use IT for instruction. The types of technology that can be applied in adult literacy programs range from computer-assisted instruction to the use of audio and video recordings and the Internet [13]. All these technologies will enhance adult instruction and learning by benefits as:

- removing or diminishing barriers to participation, including time and distance
- extending instruction into life contexts, like home and workplace
- providing access to a wide range of resources and materials for instruction
- facilitating learning for minorities with special needs and differences

The poverty cycle can be broken and by literacy learning at early ages but also at adult age [10]. The practical IT solution proposed by the authors is as an intelligent literacy tool (called by the authors iLIT) based on an embedded system approach.

The tool consist in a workspace based on a cheap thin-client (the e-Box) and a software developed in a Windows CE environment using .NET framework and C# as programming language ([5], [6], [9]). External hardware used is: a graphic tablet as pointing device, a VGA to TV converter for using a standard TV set as display, an USB memory stick and audio speakers. Main features involved are:

- friendly user interface based on voice messages and easy to read cultural suggestive icons and menus
- multi-lingual support (for minority learner)

The tool was thought as an affordable and robust alternative to expensive hardware like Tablet or Slate PCs, keeping in mind that hundred of years the ancient slate tablet was used to learn reading and writing.

Another issue was to "hide" the computer behind the application in order to fight "the computers scare" that can be found at certain adult illiterate people.

The application was developed for Romanian language, but in order for the project to achieve its overall goal of creating a stand-alone platform for fighting illiteracy, an effort was made to provide also the necessary building blocks and interfaces to help other developers extend the platform for their own language and culture ([7], [12]).

II. SYSTEM OVERVIEW

Main system components are presented in Fig. 1 with the hardware and software elements included in the system, and also the connections between them.

eBox-II (from Icop Technology) was one of the fastest Thin Client available on the market, using a Vortex86 CPU at 200 MHz and 128MB of SDRAM memory (with 8MB dedicated for graphics controller).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 499–504.
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mmeybodi@aut.ac.ir

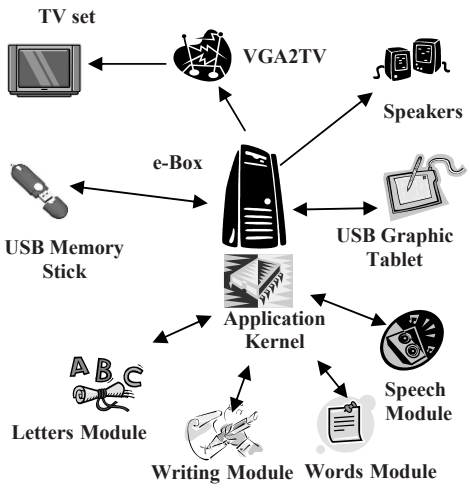


Fig. 1. System overview

There are also: an integrated accelerated 2D graphics controller, 64 MB of "Flash Disk" for storing embedded Windows CE image and applications, 10/100 BaseT Fast Ethernet connector, 2 PS/2 ports for PS2 Keyboard and Mouse, 2 USB ports, headphone and microphone connectors, SVGA monitor port, 1 parallel and 1 serial port [3].

As display, a common TV set can be used, connected to the e-Box through a VGA to TV Video Modulator. A TV set was used instead of a PC Monitor, firstly to lower the cost of the system, and secondly because a TV is found in most peoples' houses (see also Fig.2).

The application also communicates with the user by speaking to him, by means of the attached speakers to the e-Box. As a pointing device it is used a Watcom Graphic Tablet attached to e-Box through USB, tablet that allows pointing and writing in a more familiar way consistent with every day life.

The Application Kernel is the coordinator for all software modules and thus it is flashed on the e-Box. To store the additional modules and their data an USB Memory Stick is used, that offers enough space for storing a great variety of data.

A Speech Module is in a direct communication with the Application Kernel that exports its features to other modules. The Application Kernel also displays a graphical user interface, allowing the selection of individual modules.

III. SYSTEM IMPLEMENTATION

A platform Windows CE image was built for this application. Apart from the e-Box II BSP drivers, specific drivers were added for USB Mass Storage Devices and FAT file system to allow future expansions; a hard disk drive was not included from obvious reasons. The image includes the standard Windows CE GUI because future efforts will be made towards creating Learning Modules that will allow students to achieve basic Computer Skills. Graphics and multimedia support is extensive due to the audio and visual content of the Learning Modules. The minimum operating system image size was roughly 25 MB out of e-Box total of 64MB, with all needed resources and without the application code.



Fig. 2. A typical home setup of the system

An important fact is that user interface was geared for elderly people. Layout, colours and colour combinations, font types and sizes were chosen according literature recommendations and guidelines as [11].

Another fact is that all algorithms used have to be highly computational effective due to processor relatively low processing power and the lost of speed by using managed code (.NET C#).

The system modular architecture built around a kernel module is described in the following.

A. Kernel module

The kernel provides an easy-to use, dynamic interface used to launch any module that might be added to the learning platform. Its main goal is to achieve an intuitive and complete launch platform for all the future additions to the system. This is achieved by independently loading each module in its own *AppDomain* thus allowing freedom to the module developer, while the user is provided with enough information about the purpose of the module. The concept is described in Figure 2. The loader and remote loader classes provide basic loading capabilities to all the modules, while the main communication method between modules is ensured through the windows messaging system.

Due to the need for flexibility, the project relies on USB *MassStorage Devices* to provide the physical support for incoming modules. This in turn, created the need for an insertion/removal detection mechanism, and while the PnP capabilities of the platform do not provide the means for this, a watcher thread was implemented to address this problem.

This thread will watch for any changes in the directories like *\Hard Disk<#>* and will raise an event every time such a directory is created or deleted.

The *UserInterface* class manages the intuitive interface, which the user actually sees, and interacts with. Built with simplicity in mind it only has 6 pictures that also act as buttons.

The four images in the middle are the actual module buttons the images are loaded from the module directory, which must contain a bmp image with the same name as the assembly.

mmeybodi@aut.ac.ir

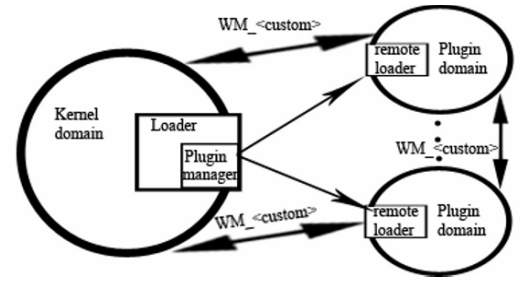


Fig. 3. Kernel module concept

The 2 lower buttons provide means to navigate through the modules, 4 at a time; when there are less than 4 modules available the correspondent image will become *<module unavailable>*.

OnMouseOver the interface will play a sound, which will explain the purpose of the module to the user. When modules are inserted or removed the interface is notified in order to prevent loading inexistent modules or not showing the newly - arrived modules

The *PluginList* is a collection, which holds the absolute paths to all the available modules at a time. The modules are indexed by the drive name and module number. These are all the required parameters for the *UserInterface* to work properly.

The *PluginManager* class will keep track of all the loaded modules and the drives they were loaded from. The Loader and *remoteLoader* classes provide basic loading and unloading means as well as probing for a particular interface in a module, and initial context passing.

B. Speech/Voice module

In order to achieve the goal of proper learning for targeted people, accurate speech modules are needed, which give proper help to the user, mainly to accommodate and navigate within the application interface, and secondly to send voice messages about current tasks, answers to user commands and accurate reading of text messages.



Fig. 4. Kernel user interface screen

There are different speech needs for iLIT modules, some imply explaining the interface usage, others to reproduce a text who can be in played in plain words or spelled by letters, or to read the message (words or letters) written by the user on the graphic tablet, also spelled by letters. In order to accomplish all these, the speech engine has methods to play the whole message or to split messages in letters and play them in corresponding order, or to combine the two methods one after another.

These tasks can be accomplished using two basic design approaches, one using a Text-To-Speech (TTS) technology to convert text commands/messages to spoken words and seconds using prerecorded audio message (commands, words, sentences and letters). The TTS technology represents a better storage space saver and implies a lesser work for the module creator, reducing the time needed for recording audio samples, but the problem with this implementation is that it uses grammar rules different for every language, and there are a lot of languages without a proper TTS engine implemented. The communication between the command module and speech module is ensured through the windows messaging system when a proper message is sent to speech module. The message contains information about the audio file to be played, the desired method of speech, whole word or spelled by letters.

To reduce the needed storage space, audio samples are normally compressed using MPEG Audio Layer 3 codec. But there is also a list of common audio samples to be played, for example letters that are frequently used, and in order not to waste processing power to decode them, they are stored as uncompressed PCM audio files.

The main class is *SpeechEngine* who manages the sound playing requests. This class translates the received message from any other module, parses and processes the message in the appropriate way. For example, if the message contains a valid path to a MP3 file, it plays the audio, and then it will or will not spell by letters the sent message. The *SpeechEngine* knows that the text representation for every message that will be spelled is the name (without path and extension) of the requested audio file to be played. If the string from the message is not a valid path, the string will be spelled.

For playing the whole audio file, it chooses the *SpeechEngine.Play()* function that uses *MP3Player* class to play that file, and for spelling *SpeechEngine.Spell()* that splits the message in letters and uses the *WavePlayer* class to play the files corresponding to each letter. The *WavePlayer* class has a list of audio streams corresponding to each letter that is loaded in memory at first usage and that can be played by the *Play(),* function which splits the message in letters.

The *MP3Player* and *WavePlayer* classes implement the *AudioPlayer* interface. The code is language independent, the only thing that needs to be modified for translations being the alphabet and its corresponding audio files. The module was tested for performance during the implementation, and that's why the sounds for letters (which are frequently used) are stored in uncompressed files and loaded in memory at first usage.

C. Learning the alphabet- the Letters Module

This module focuses on presenting the letters of the alphabet, one by one, to the user, and testing the user's

mmeybodi@aut.ac.ir

abilities to learn each letter, by testing him twice for each letter. The tests consist of checking from a grid of random letters only the correct ones.

The main classes for this module are presented in the class diagram. The main application class is *LearnToReadModule1* that contains an instance of *TabletInterface* that represents the backbone for the user interface.

The *TabletInterface* class was designed to be easily used as the backbone for future implementations. It consists in a number of 28 buttons, each having an identification number from (0…27), arranged along a center drawing panel. The buttons of the *TabletInterface* were considered instances of *PictureBox* from S*ystem.Windows.Forms* so that pictures could be applied on each of them. Also behind the buttons and the drawing panel, we placed another *PictureBox* that represents the background of the user interface. The drawing panel placed in the center of the screen is an instance of *System.Windows.Forms.Panel* and represents the workspace for the *LearnToReadModule1* or another module. The *TabletInterface* can be applied on any given *Form* and its buttons can be easily customized once this class is instanced.

LearnToReadModule1 class represents the core of this learning module, guiding the user through the alphabet and testing him to decide whether he has learned the letter and can advance to the next one.

Previous Learned Letter Button allows the user to view the letters that he has learned so far. A pressing of this button switches between the current displayed letter and the previous letter of the alphabet. The *Next Letter Button* changes the displayed letter to the next letter of the alphabet. If the maximum letter was reached, that is the next letter to be learned by the user, this button hides itself. *Advance to Test Button* leads the user to tests for the current letter or to the next letter if the user passed test 2 for the current letter. *Exit Application Button* leaves the application and saves, using the *XML_Module1* class, the needed information for a later run of the module.

D. Words Module

After the user got familiarized with all of the letters, he/she can use this module to learn how the letters are linked together in words.

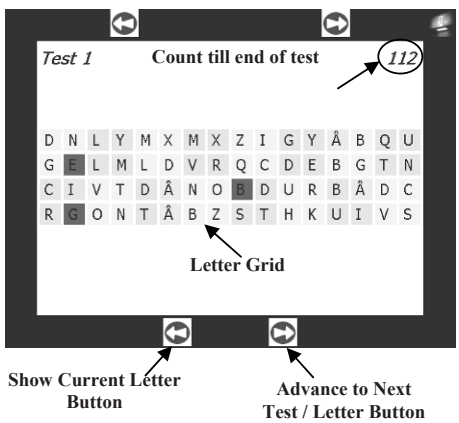


Fig. 5. Letters module test screen

The words that will be presented refer to entities that the user is already familiarized with, this approach ensuring a fast learning process. A bunch of words that may not be part of the user's life are also included, increasing his/her general knowledge. Anyway, the words list can be easily customized by the software support personnel, based on each user's living environment, habits, etc.

This module consists of two sub-modules: first one is used for presenting the words to the user, and the former for allowing the user test his reading abilities acquired during the presentation.

Three more buttons are available, two for navigating through the words, and one for replaying the current word. The presentation of a word consists of displaying the image of the object that the word refers to, and then the word is spelled letter by letter both visual and audio.

Because the button that is implemented by .NET Compact Framework does not allow displaying an image on it [14], we created our own *CImageButton* class which is derived from the standard *Control* class. Any button can be instantiated by *CImageButton* in two ways: with an image on in and with text (as a standard button, but with a different look-and-feel).

The former *CImageButton* instances are used in the *Words Test* sub-module, for displaying the letters, but it is intended to put text on buttons in advanced modules, when the user will have enough reading proficiency. For easily changing the layout, the *CImageButton* class provides public properties that allow changing the caption, the image and the sound that will be played when the mouse is over the control.

Words Test; After the user gets familiarized with the words presented in the above sub-module, he can click on the next option in the upper left of the screen for taking a test. The test consists in displaying an image (from the ones used during the presentation), while the user tries to choose the correct letters to compose the corresponding word.

As seen in the picture, there is a button matrix at the bottom of the screen, each button containing a letter. In order to compose the word, the user must click on the button that contains the next letter in the word.

The system waits until the user clicks on the correct button, each mistake raising an audio message. When the entire word was completed, it automatically passes on to the next word.

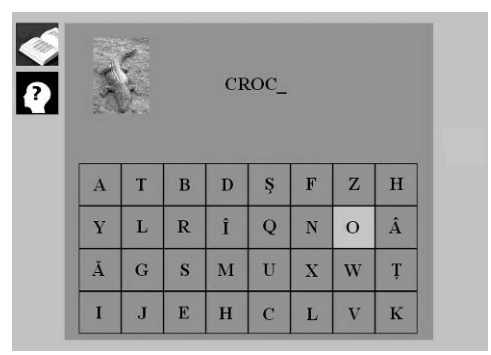


Fig. 6. Words module screen

mmeybodi@aut.ac.ir

For enforcing the user to click on the correct letters, without automatically learning the column and row number of the button that must be pressed, the letters are generated in a random order. In addition, the buttons may contain symbols other than letters. A fast algorithm for this task is proposed. An index array initialized with letters, in the order they appear in the alphabet it is used. Then a random number N is generated, representing the number of permutations that will be made. This number should be big enough to ensure a good shuffle of the letters. Then *N* permutations are made, at each step two random indexes being chosen and the elements that are found at these positions being swapped.

The user interface related classes were kept apart from the classes that handle the back logic of the application, allowing easy change and debug of the functionality without changing the front interface.

E. Learning to Write - Writing Module

The aim of Writing Module is to create and improve the user's writing capabilities. The user must draw an approximate shape of the letter that is displayed to him, and can advance to the next letter if it's decided that what he drew is 70% similar to the displayed letter's shape.

Consider, for example, that the user is in the process of learning to write the letter "A". The user interface used for write training is shown in Fig. 7.

The user interface updates with the letter and its corresponding picture, the user is told using voice messages about the letter that he must draw and the suggestive word that contains this letter. The *Drawing Board* represents the area where the user must draw the letter presented to him in the upper left corner.

Below the presented letter is placed a suggestive picture of a word, e.g. "Acordeon" that contains the letter "A". If the user decides that what he drew is wrong, he can always clear the *Drawing Board* by pressing the *Reset Board Button*. If it's decided to leave this module, the *Exit Application Button* does it If the user considers that what he has drawn is correct and wants to advance to the next letter he has to press the *Next Letter Button*, which leads the user to the next letter only if the letter drawn represents at least a 70% approximation of letter "A".

As a skeleton for the user interface the *TabletInterface* class was used, presented earlier, in the iLIT's Letters Module. On the drawing panel of the *TabletInterface* for the shown letter's representation, the displayed picture, and drawing board *PictureBox* objects were used.

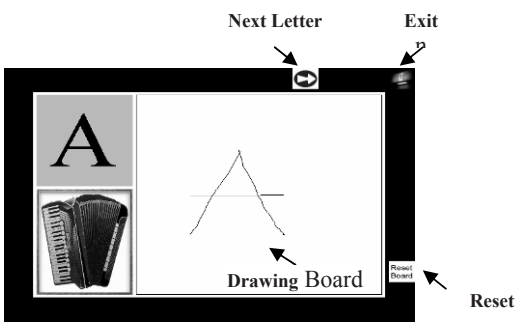


Fig. 7. Writing module main screen

Writing recognition algorithm behind the user interface is the decision factor that lets the user advance to the next letter. Hand writing recognition algorithms involve training the software to recognize each letter. The training process is required, because it is almost impossible that the final user would draw the same letter in the same way, each time. What the user draws will be always an approximation the correct shape of the letter, the approximation degree depending on different factors, such as user's handiness (which should be very low for the intended users), precision of the pointing device, etc.

An additional tool called *CharTrainer* was created, that assists the process of training the characters. This has a simple interface that allows drawing a character, calculating a signature and saving this signature to a binary file. For example, the letter *A* is drawn and the signature saved in the file *A.dat*. When the final user is required to draw the letter *A* in the *Writing Module*, the signature for his drawing will be calculated, and then compared with all of the signatures found in *A.dat*. If the new signature fits with one of the existing signatures, then the user has drawn the correct letter. For the writing algorithm to work properly, the software must be trained to recognize dozens of shapes for the same letter. As an improvement of the comparison process, only an average signature is stored in the binary file, the algorithm being reduced to only one comparison. When *CharTrainer* adds a new signature vector, it will increase the number of signatures, and update the average signature. *CharTrainer* was designed so it can be configured to work with different pattern recognition algorithms, by only changing the function that calculates the signature.

IV. RESULTS AND FUTURE DEVELOPMENTS

First modules developed and tested proved that such a solution is a viable one and could be further developed to its end-goal of bringing education and knowledge closer to those who need it.

Such system through modularity, ruggedness and the ability to operate remotely on common and inexpensive hardware could prove to be a way for aiding remote or isolated communities in achieving at least a basic level of education.

More modules are planned, with current work focused on optimization, on improving the existing algorithms and the user interface. One algorithm that it is a candidate for improvement is the one used by the Writing module. Alternatives are now considered to the pattern recognition algorithm currently used, so a choice will be able made for the one that is faster and well suited to be used by persons that do not have good writing abilities yet.

A quick overview of other possible additions:

- User tracking and profiling, intended to provide a valuable tool for teachers and instructors, in assessing a user's knowledge, to identify knowledge gaps and areas where the student needs further assistance.

- Network connectivity, allowing a teacher to work with several students remotely, over the Internet and also allowing teachers to reach remote areas without the need of physical presence.

Another actual direction of development is using the last version of Icop's e-Box, the e-Box-2300. The new e-Box is practically a small, low-cost VESA PC with same

mmeybodi@aut.ac.ir



Fig. 8. iLIT application on display at WESC 2005 Final at Microsoft, Redmond, WA

connectivity as e-Box II, but using as system FLASH an external SD FLASH card [4]. The application was also ported without difficulties on the new Windows CE 6.0

Other tests are planned with different input devices like pen and low cost touch-screen add-ons (overlays), with USB interface. The reason for using such an overlay is that it could be easily mounted also on a standard TV set.

ACKNOWLEDGMENT

The work presented in this paper is partially based on the report presented by a team from University of Craiova at the final of the Microsoft's contest Windows Embedded Student Challenge 2005 [12].

For this contest Microsoft Corp. provided the needed software, basic hardware (e-Box II) and support in order to achieve these results.

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mmeybodi@aut.ac.ir

The G^2 Project: Establishing A CSU "Grand Grid" for Scientific Computing in Research and Education

Spiros H. Courellis, *Member, IEEE*, Katherine A. Kantardjieff, Robert Chun, Kimberly Cousins, Patrick Fleming, Nicholas Kioussis, Brooke Lustig, Dragutin Petkovic, Shantanu Sharma, William Thibault, and Farmaraz Valafar.

***Abstract*—The G^2 project reflects a systematic effort to functionally link computational resources across all California Sate University (CSU) campuses. The result is a CSU wide Grand Grid that provides a computing ecosystem where Computational Resources within and outside CSU can join in fully or partially while they maintain their autonomy. The Grand Grid provides interfaces for secure and efficient interaction among distinct administrative domains depending on the classification of the user accessing a service on the Grid and the hosting site(s) of the applications supporting the service. The current computational state, the architectural principles, and a high level blueprint of the Grand Grid are presented in this paper. Globus Toolkit v4 is presented as the leading candidate for middleware on which the Grand Grid is being built, and an initial set of participating CSU computational resources that help in shaping the Grand Grid is introduced.**

I. Introduction

GRID Computing is an emerging technology integrating distributed, diverse computational resources into a scalable super computing force capable of efficiently tackling challenging computational problems [1,2]. It has revolutionized many fields of technology, with key applications in several areas of science and engineering [3]. Computational techniques applied to modeling and solving problems in Science and Engineering can provide a unique insight and often facilitate research and education efforts, complementing activity in the classroom, the lab, and the production floor. Much like in other institutions and the industry alike, at the California State University (CSU), one of the largest educational institutions in the world, we are faced with the existence of several Computational Clusters serving various scientific applications that operate as isolated, unleveraged islands of scientific competency. Therefore, the need to create a computational ecosystem that will provide a vehicle to bring all of them together in a consistent and organized manner is critical. Such a computational ecosystem significantly strengthens CSU's position in research and education and makes CSU a powerful resource for Scientific Computation statewide and globally.

The G^2 project is the answer to this need. Its efforts focus on creating a grid enabled compute infrastructure that allows owners of computational resources at CSU to join partially or fully and to leave CSU's Grand Grid at will. They also focus on laying the foundation for the development of a culture and a set of practices that promote developing, deploying, utilizing, and sharing Grid-Enabled applications in support of scientific and engineering research and education. At the center of this grid-enabled computational ecosystem is the Grand Grid. A collection of hardware, software, and programming practices that presents a consistent interface to the users who consume services on the grid and to computing resources that join the Grand Grid to provide such services. It is based on a set of principles that address the massively distributed nature of CSU among its 23 campuses, the large diversity of existing computational clusters within each campus and across campuses, various security requirements at the campus and the local level, and the need for autonomy expressed by practically the owner of every computational resource. In this paper, we present a high level blueprint of the Grand Grid, some of its implementational aspects, and a set of initial participants as they influence the shape of the Grand Grid.

II. The Grand Grid

The CSU Grand Grid is based on a philosophy that promotes

Manuscript received October 22, 2007.

Spiros H. Courellis is with the Computer Science Department, California State University, Fullerton, CA 92835 (phone: 714-278-7304; fax: 714-278-7168; e-mail: shc@ecs.fullerton.edu).

Katherine A. Kantardjieff is with the Department of Chemistry and Biochemistry, California Sate University, Fullerton, CA 92834 (e-mail: kkantardjieff@fullerton.edu).

Robert Chun is with the Department of Computer Science, California Sate University, San Jose, CA 95192 (e-mail: rchun@cs.sjsu.edu).

Kimberly Cousins is with the Department of Chemistry, California Sate University, San Bernadino, CA 92407 (e-mail: kcousins@csusb.edu).

Patrick Fleming is with the Department of Chemistry, California Sate University, San Jose, CA 95192 (e-mail: pfleming@sjsu.edu).

Nicholas Kioussis is with the Department of Physics, California Sate University, Northridge, CA 91330 (e-mail: nick.kioussis@csun.edu).

Brooke Lustig is with the Department of Chemistry, California Sate University, San Jose, CA 95192 (e-mail: blustig@science.sjsu.edu).

Dragutin Petkovic is with the Department of Computer Science, California Sate University, San Francisco, CA 94132 (e-mail: dpetkovic@cs.sfsu.edu).

Shantanu Sharma is with the Department of Chemistry, California Sate University, Pomona, CA 91768 (e-mail: sks@csupomona.edu).

William Thibault is with the Department of Mathematics and Computer Science, California Sate University, Hayward, CA 94542 (e-mail: william.thibault@ csueastbay.edu).

Farmaraz Valafar is with the Department of Computer Science, California Sate University, San Diego, CA 92182 (e-mail: faramarz@cs.sdsu.edu).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 505–508.
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mmeybodi@aut.ac.ir

a distributed, flexible, extensible compute ecosystem, where services are made dynamically available for user consumption by Computational Resources that host, maintain, and administrate the applications providing these services. The high level blueprint of the Grand Grid is based on a set of requirements expressed by an initial set of participating computational resources as they were captured in the past and recently confirmed by a survey conducted by one of the coauthors of this paper (K. Kantardjieff).

A. Requirements

One key requirement for participating in the Grand Grid expressed by practically every CSU Computational Resource is *autonomy.* Resources are willing to place themselves in the computational environment of the Grand Grid under the condition that the local system admin(s) would decide when and to what extent each service provided by the Computational Resource becomes available to external use. A second key requirement is concerned with security and trust. User authentication and service access need to be addressed dynamically and at multiple administrative levels. Computational Resources should not have to adopt one common security technology. They will maintain their security solution and be able to interoperate with other computational resources through the Grand Grid security framework. A third requirement deals with resource transparency. A user should not have to know the exact location (by name or address) of the service wishing to consume. Services advertise their availability, capacity, and level of access dynamically over time and users are able to query service availability and decide how to use them based on the parameters under which services are available. These parameters are defined by each service as it becomes available and, in general, vary over time. A fourth requirement is pertaining to flexibility. Resources should be able to dynamically join and leave the Grand Grid and change their level of participation dynamically. That is, a service may be allocated by the hosting Computational Resource hardware and software resources that vary over time from 0% to 100%. Computational Resources can reduce the support of a service to 0% at any point in time. If such a reduction is introduced during the consumption of a service, an appropriate message is to be generated to inform the user about the action. A fifth requirement is associated with the creation of a well documented and widely published methodology for Applications and Users to interact within the Grand Grid, allowing programmers in each Resource to enable local applications to join the Grand Grid and users throughout CSU to consume services advertised within the Grand Grid.

B. Architectural Framework

Considering the key requirements discussed in (A) above, for CSU Computational Resources to participate in the Grand Grid, an *Architectural Framework* is being developed that addresses the key functional areas identified above: Autonomy, Security, Transparency, Flexibility, and Interactivity. These functional areas are supported by three broad technical areas: Integration Infrastructure, Application Development, and Application Utilization.

The Grand Grid is logically partitioned in four hierarchically structured Administrative Domains: the Computational Resource Domain, the IntraGrid Domain, the ExtraGrid Domain, and the InterGrid Domain (Fig. 1). Each Computational Resource deploys and maintains its own security technology for users to authenticate and access its services directly. An IntraGrid Domain is comprised of rather closely collaborating Computational Resources that share the highest level of trust. IntraGrid Domains can be bound either by geography or by functionality, or by both. The ExtraGrid Domain is the administrative domain that defines the interaction among the various IntraGrid Domains. It has a presence in all CSU campuses or at a minimum in those campuses that include IntraGrid Domains. The ExtraGrid Domain is the largest administrative Domain that aggregates all computational resources within CSU. The InterGrid Domain is the administrative domain that allows interaction between Computational Resources or aggregates of Computational Resources within CSU and other computational resources outside CSU, whether they belong to other educational or government institutions or industrial collaborators. As this interfacing may occur at any CSU campus, InterGrid presence could potentially exist at all CSU campuses.

Communication among Computational Resources within and between Administrative Domains is typically supported by Layer-2 and Layer-3 network infrastructure solutions with varying levels of security, depending on the information security rules at various CSU campuses. Such solutions utilize mostly existing network infrastructure and can be as simple as a dedicated VLAN, to VPNs, to dedicated security solutions.

Services advertised on the Grand Grid and consumed by the Grand Grid are supported by software infrastructure which is part of the Architectural Framework of the Grand Grid and includes public domain software extended and adapted to address interactivity within the Grand Grid. Services are authenticated into the Grand Grid and Registered into the Grand Grid's registry defining a set of parameters they can modify dynamically. Applications supporting these services are extended or "wrapped" with software in order to interact with the Grand Grid. Clients that consume services on the Grand Grid are also extended or "wrapped" to be able to use Grand Grid Services. Clients dynamically discover the services they wish to consume and evaluate the parameters provided by each service to allocate the appropriate resources to the task(s) they plan to execute. Besides dynamic discovery and self-optimization, the software infrastructure supporting the Grand Grid provides notification and notification handling capabilities. The need for this capability is particularly clear in the event that a

mmeybodi@aut.ac.ir

service decides to scale down its availability in the middle of the execution of a task, a CSU Grand Grid feature addressing the requirement for preserving the Autonomy of each Computational Resource. Users can also invoke Grand Grid services through a middleware layer that is platform neutral and relieves the user form having to develop software extensions or software wrappers to enable his/her current software to use Grand Grid services and/or to optimize the selection of the resources required to execute the requested task(s).

C. Network Topology

The Grand Grid uses the existing CSU network topology and the topology of the various Computational Resources as they have already been deployed. Although in certain instances higher bandwidth links may be required due to the utilization patterns of a service, the Grand Grid does not impose rigid constraints on the deployment or the reconfiguration of network routers and switches. Various Computational Resources can incorporate most or all of the components required for the formation of an IntraGrid or, alternatively, dedicated equipment may be deployed in each campus to support the IntraGrid functions. It is anticipated that ultimately at least one such set will be available per campus to accommodate resources that do not wish to directly support IntaGrid infrastructure. Similarly, dedicated

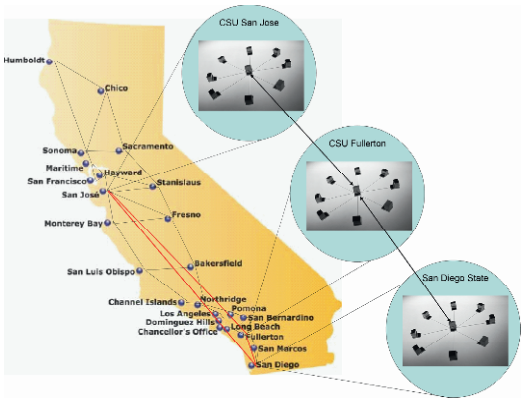


Fig. 1. CSU Campuses across the State of California that the Grand Grid is expected to service. The inset shows examples of campus specific IntraGrids as they are aggregated to form the CSU ExtraGrid.

equipment will be ultimately made available in each campus to support the ExtraGrid and the InterGrid functionality. It is expected that the IT organization of each campus will play an important role in integrating and supporting this equipment.

D. Software Infrastructure

The software infrastructure necessary for the deployment of the Grand Grid is based on currently available middleware that can be extended to accommodate the idiosynchracies of our environment.

Among the currently available middleware packages, we consider, the leading candidate is *The Globus Toolkit v4 (GT4)*[4]. Its new, service oriented architecture utilizing web services is providing a consistent, uniform, and well established mechanism for integrating applications into the grid and consuming services from the grid. The convergence of Open Grid Services Architecture (OGSA) and the Web Services Resource Framework (WSRF) on GT4 [5] together with the numerous GT4 extensions publicly available provide a foundation that can be flexibly adjusted to accommodate the computational heterogeneity that needs to be supported by the architectural framework of the CSU Grand Grid.

E. CSU Computational Resources and the Grand Grid

Computational Resources within the CSU system offer a variety of services spanning a number of areas in science and engineering. Their computational infrastructure includes a variety of hardware and software platforms that collectively constitute a heterogeneous compute environment. A recent survey indicated that Intel based clusters are dominating with Linux being the most frequently encountered operating system. A variety of cluster support software has been deployed, ranging from vendor specific solutions to several Open Source solutions. Both vendor proprietary applications and open source applications have been deployed with no clearly one being the dominating category. The following are examples of Computational Resources within CSU that host Grid-enabled services: *Grennache* (Grid Enabled Applications for Computation in CHEmistry) [*http://chemsrvr2.fullerton.edu/grennache*] and *tgrid* [*http://tgrid.ecs.fullerton.edu*] are Computational Resources at CSU Fullerton; *CompCore: Cyberinfrastructure for Interdisciplinary Research* [http://www.compcore.csueastbay.edu/] is a Computational Resource at CSU East Bay; *CMTC* (Computational Materials Theory Center) [http://www.csun.edu/~nkioussi/] is a Computational Resource at CSU Northridge, *CM^{3}D* (Center for Macromolecular Modeling and Materials Design) is a Computational Resource at CSU Pomona; *CSRC* (Computational Science Resource Center) and *MSARC* (Macromolecular Structural Analysis Resource Core) [http://www.csuchico.edu/csuperb/MSARC.htm] are Computational Resources at CSU San Diego; *CCLS* (Center for Computing for Life Sciences) [http://cs.sfsu.edu/ccls/] is a Computational Resource at CSU San Francisco; and *SJC* (San Jose Cluster) is a Computational Resource at CSU San Jose.

III. DISCUSSION

The G^2 Project reflects an effort to collectively address sharing Computational Resources within CSU in a uniform and consistent manner. It uses commonly agreed upon procedures and a flexible technical infrastructure to support secure integration of heterogeneous compute resources

mmeybodi@aut.ac.ir

while it preserves local autonomy. It also aims to create a community of Scientists and Engineers within CSU who integrate computation into their research and education activities, whose influence and strength are expected to have statewide and global impact.

The CSU Grand Grid provides the "hooks" to integrate computing clusters created by individual faculty members and departments throughout CSU by means of intramural and extramural grants that run specialized applications supporting a number of projects associated with Science and Engineering. The high level architectural blueprint of the Grand Grid presented in this paper is set up to address interaction among the large collection of these diverse Computational Resources and to accommodate a set of evolving requirements. It has a certain level of flexibility that allows for adaptation as technology and scientific methods evolve and as collaborative activities within CSU, and between CSU and other institutions are dynamically formed and dissolved.

Considering the degree of collaboration that could potentially foster and the plethora of services for scientific and engineering exploration it could offer, the Grand Grid is expected to have significant impact on faculty development, student research, and curriculum enhancement. In terms of research and development, detailed complex scientific and engineering problems and environments will be modeled more accurately and reliably, complementing any experimental activity planned subsequently or concurrently, or already performed. Using grid-enabled distributed resources, students and faculty will work collaboratively, sharing expertise, resources and mentoring to effectively educate and train the next generation of scientists and engineers. The Grand Grid is expected to play an important role in education also as a national and international computational resource serving predominantly undergraduate institutions.

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mmeybodi@aut.ac.ir

Teaching and Assessing Graduate Ethics in Engineering, Science, and Technology

Steve Roach and Jules Simon

Abstract— **Educating scientists and engineers with respect to the ethical implications of their professional actions is an increasingly urgent, demanding, and complex task, and we do them and society a disservice if they inadequately grasp the ethical significance of the work they do. Education in ethics in engineering and the sciences has been recognized as intrinsically important. The Institute for Science, Technology, Ethics, and Policy at The University of Texas at El Paso brings together scientists, engineers, and philosophers from the academic, industrial, and public policy domains to focus on training both graduate students and faculty in ethical theory related to science and engineering. This training will focus on the rigorous development of ethical thought as applied to current topics in the science, engineering, and technology sectors. Because education in ethics necessarily involves subjective as well as objective factors, in order to evaluate the efficacy of this approach, an innovative assessment of student development that integrates both quantitative and qualitative approaches needs to be made. This paper describes such an experimental method that will be used to assess students for an ethics in engineering course.**

Index Terms— **Ethic in Engineering, Ethic in Computer Science, Ethic Education, Ethical Theory Training, Assessment of Training**

I. Introduction

Ethical issues frequently arise in the practice of engineering and science, and ethics educators at both the undergraduate and graduate levels have been struggling to keep pace with the rapid changes in science and technology [3, 18]. A number of institutions host web sites with down-loadable modules and case studies. (See for example [19].) One of the standard methods for educating graduate students and faculty in the ethical concerns associated with engineering and scientific research and professional practices has been (and continues to be) to rely on testing students and teachers for their ability to apply professional ethical codes associated with a particular discipline. Any instructor can then pick up a module, test their students on applying the appropriated material to a set of well-established, empirical case studies and be done with the requirement to cover ethics. The merits in adopting this pedagogical approach have to do with the ease of integrating such teaching modules into already overburdened curricula and understaffed departmental units. But this particular practice is one of the many controversial methodological issues involved in how training in a system of ethics is conditionally linked to the quality of research in ethics as it is related to an individual disciplinary system. The problem is that while in theory, certain standards of practices can be codified for general applicability to any research or professional project; in practice the ever-changing material dealt with by scientists and engineers is precisely of the sort that pushes the limits of ethical guidelines. Moreover, ethical decisions necessarily take the form of subjective judgments; thus, pre-packaged teaching modules often only graze the surface of the ethical considerations and capabilities intended in an undergraduate science or engineering program.

Even with readily available modules and case studies, an additional impediment to the inclusion of ethics education in science and engineering course is the opinion that ethics should be taught by faculty with degrees in ethics, and not by scientists and engineers [6]. The mass-production of such modules and case studies in the last few decades to complement the discipline-specific codes of ethics indicates the noble attempt by engineers and scientists to remedy on their own the real need to address the growing problem of the need for a more nimble and comprehensive approach to educate engineers and scientists in the ethical issues involved in their professions.

Complicating this endeavor is the unavoidable condition that "exploring ethical presuppositions" also entails familiarity with both the dominant ethical paradigms, such as virtue (or character) ethics, deontological (or duty) ethics, and utilitarian ethics but also the many contemporary ethical orientations that have emerged in the last century. Orientations such as cultural relativism, emotivism, pragmatism, intuitionism, and discourse ethics have emerged, in large part, precisely as a response to not only the unprecedented nature of advances in technology and the computer sciences in particular, but advances in engineering and the natural sciences in general. See, for example, [10].

Manuscript received October 22, 2007. This work was supported in part by the National Science Foundation under Grant IIS-0734912.

S. Roach is with the University of Texas at El Paso Department of Computer Science, El Paso, Texas, 79968 USA (915-747-5727, sroach@utep.edu).

J. Simon is with the University of Texas at El Paso Department of Philosophy, El Paso, Texas, 79968 USA (915-646-7912, jsimon@utep.edu).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 509–513.
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mmeybodi@aut.ac.ir

II. Institute for Science, Technology, Ethics, and Policy

The Institute for Science, Technology, Ethics, and Policy (ISTEP) at The University of Texas at El Paso (UTEP) seeks to provide an alternative vehicle for teaching and research focusing on ethical dimensions involved in the related fields of engineering and the sciences for groups of graduate students and for faculty, including the active participation of industry professionals and policymakers. Moreover, an organizing principle that sets ISTEP apart from others is our desire to institutionally cultivate the dimension of systematic embededness of ethical concerns and practices that occur across these interrelated knowledge, production, and socio-political policy domains. Research at ISTEP brings to bear precisely the sort of work that philosophers do in exploring the ethical presuppositions of any authoritative or scientific domain to stimulate the kinds of research and activities in the field of teaching in ethics, engineering, the sciences and public policy that global developments in the twenty-first century demand.

Clearly there are already a number of good sources for ethics information and support relating to engineering, science, and public policy [4, 7, 9, 13, 16, 20, 21, 22]. We believe that ISTEP can establish a program that builds on past efforts that will also have unique and timely aspects. For instance, to address the ethical challenges that multiculturalism and internationalism present to the engineering profession, as the top engineering graduate school for Hispanics [11], UTEP can readily involve minority students in its activities [1]. Since UTEP is located on the Mexico-U.S. border, it had to develop working relationships with Mexico, Mexican professionals, and policy makers. Many of UTEP's students, especially in engineering, are Mexican nationals and will return to their country after graduation. Such students provide an excellent chance to understand the consequences of different professional ethics and to test the extent to which training in ethics, as understood in the United States, can and should be related to ethical issues in other countries. As an example of how international considerations affect societal issues, the College of Health Sciences has a primary research focus on minority health and how the health system as a whole responds to minority and early generation immigrants. Many UTEP students and community professionals come from a tradition of suspicion and mistrust of the government and its rules. Making a case for following (the sometimes flawed) professional and educational practices in the United States is not trivial [19].

III. Goals of graduate engineering Ethics education

One of ISTEP's primary goals is to establish practical structures to better educate graduate students to not only become more aware, but also to become more actively engaged in the work being done within the various groups working at the Institute. The global and international consequences of better attending to ethical dimensions in the ever-more tightly interwoven practices of academics, industry engineers and scientists, and public policymakers is becoming increasingly evident. Thus, we have initiated collaborative and interdisciplinary research projects originating from the relationships that we hope to foster between graduate students, resident and visiting scholars, and invited professionals and policymakers. Our research brings to bear the often-competing perspectives and intentions of various practitioners from disparate but related disciplines and members from within those disciplines in varying levels of training or expertise, from novices to experts. Such multidisciplinary and intra-disciplinary projects are essential for not only better understanding, but also for improving the quality of relationships with each other in the world.

In theory, if the small group of researchers and associates already connected with ISTEP directed their efforts toward improving the kind and quality of research and information technology practices at the UTEP site alone, there would be work enough for decades to come. This is one compelling reason why we are so invested in our students. Indeed, our goals are much broader in so far as we recognize that the changes in educational praxes that we are attempting to institute can only be accomplished by educating students to become better aware that the world in which they are already living and will be working is radically pluralistic with an international and multicultural context.

Our initial goals include introducing our graduate engineering and computer science students to the challenging ethical complexities that are part of every research agenda and project assignment that they will soon be undertaking as members of the workforce. In other words, ethics education for graduate engineering students should be recast as arguably the most pragmatic and pressing dimensions of their preparation.

IV. Example Issues

An example of a contemporary scientific practice that has substantial ethical implications was recently encountered by an ISTEP associate teaching a bioethics course. At issue is the practice of splicing or dividing research results. Suppose a researcher has received funding from a government agency such as the National Science Foundation (NSF) or the National Institute of Health (NIH). The proposal specifies the bounds of the research to be conducted. At the end of the contract, the researcher publishes most, but not all of the results that were derived from the research effort. The researcher then writes another proposal that overlaps the original proposal. The issues include the support of researchers in the laboratory, the potential benefits of the

mmeybodi@aut.ac.ir

community interested in the results, and the deception of the funding agency. The situation is further complicated if the laboratory is supported by several related research grants that may or may not be overlapping in scope. To gauge the depth and extent of this problematic area, see [15] and [2].

As this paper indicates, one of the specific goals of ISTEP is to advance the ethical thinking of engineering students so that they can analyze matters such as this in terms of ethical points of view as opposed to relying on erroneous or misinformed patterns of behavior. To accomplish this for an engineering student could entail engaging her in the relatively simple task of setting up a Web page for the class within which she is working or revising one of the many Departmental Web pages at UTEP that are in constant need of updating. As a matter of course she would have a limited time-frame to accomplish this task with instructions that the Web page has to include at least 50% new material and that it has to have elements of at least three other model Web pages that she has found through her research on the internet. In this way, she will be confronted with the practical demands of ethical issues in her own discipline, such as copyright laws that apply to internet-published material. For instance, under pressure to create 'original' content, she may be tempted to copy-and-paste lists of resources (en bloc), already published images, or this or that series of html, xml, or other unique markup language sequences. We would expect her to be able to articulate the ethical reasoning behind why such an action is or is not ethical.

Other examples of issues associated with engineering ethics include:

- Can, and do, engineers make a difference to the degree to which technology leads to morally desirable outcomes? What role does professional autonomy play here, and what are its limits? And secondly, what should be the scope of an engineer's responsibility; that is to say, on which issues are they, as engineers, morally obliged to reflect?
- Researchers in the natural and physical sciences, the social and behavioral sciences, and engineering all grapple with privacy issues in their research. The issue of privacy arises in field studies of populations and laboratory studies of individuals. It arises in the design of computer systems and engineering artifacts. How has graduate education incorporated, or how might it better incorporate, attention to privacy concerns? How do graduate students, postdoctoral fellows, and faculty identify the relevant questions and address them? Are there examples of best practices?
- What is the relationship of standard codes of ethics to new developments in technology and the sciences?
- What role do or should cyber-communities have with academic and professional communities, with industry, political, and religious communities, and with intercultural communication?
- How can educators, industry professions, and policy makers provide for bio and cultural diversity through providing clues for building credible and sustainable design alternatives that will not hurt others?
- What is the nature and function of intellectual copyright law, the patent system, outsourcing, reverse engineering (in the context of taking an existing design and producing it for cheaper), and the fluctuating parameters and standards of scientific publishing?
- Should one work on a new version of software knowing that the reason there is a new version is to sell more copies?
- Should one embed code in a software program that identifies the purchaser?
- Should one use or modify a program that is the best that you can do, but that you know will be misused by others?

Of course, a long list of many other issues in these rapidly changing fields could go on for several pages. Among those many others, the following concerns could also eventually be taken up in one way or another through the research and teaching functions of the proposed Institute: computer security, technological obfuscation, piracy, computer viruses, bioethics/bioengineering, nanotechnology, neuroscience, tracking devices such as RFID, biometric analysis and identification, genetic screening, open-source software (Linux, Java, the GNU public license software, to name a few), digital rights management, or form/function distinctions involved in liability, infringement, and other issues such as access-control technology associated with the Digital Millennium Copyright Act or the European Union Copyright Directive.

V. ISTEP'S APPROACH TO ETHICS AND ASSESSMENT

Our approach to teaching ethics is, in the first place, dictated by our choice to work together as colleagues from different disciplinary backgrounds but with investments in each other's professional commitments. Secondly, it is just as strongly motivated by our desire to generate new and relevant approaches to educating students in better understanding the ethical challenges that they will inevitably face as professional engineers and scientists in a world that will remain culturally, economically and nationally diverse.

We are convinced that teaching ethics is a profoundly personal phenomenon that has broadly public consequences. Thus, it is imperative that the context for teaching ethics becomes one that takes into account the need for demanding very different sorts of teaching practices than the typical engineering student may encounter in a highly structured program of study. What this means in practical terms is that students will be asked to provide more reflective and philosophical accounts for their choices in making a judgment, enhancing their awareness of the complexity and demands of their involvement in the project at hand.

mmeybodi@aut.ac.ir

Typically, they will be asked to objectively define the terms that they use in the arguments that they propose for justifying a judgment in a given situation.

Minimally, they will be expected to demonstrate a working familiarity of ethical concepts and conceptual relations within the written context that they establish for their arguments. This approach depends upon our success in developing an awareness of the ability to not only recognize the ethical components of issues, but also the ability to express and defend a position with respect to an issue. What is more difficult to measure, however, is the subjective impact of this course of study because, in fact, teaching ethics unavoidably entails a subjective element of decision-making. Our recognition of this unavoidable subjective element and attempt to integrate that element in an institutional teaching context is one of the significant aspects of what sets our approach apart from others. This accounting for the role that subjectivity plays in ethics is necessarily closely related to how we understand the role of more formal vehicles for assessment.

Assessment is the systematic collection of data by the providers of a particular graduate course in Engineering Ethics that will be offered through the interdisciplinary aegis of ISTEP. Standard methods for measuring students' abilities for mastering a variety of modes of ethical reflection, conceptualization, and expression will be administered in the form of series of writing, speaking, and testing exercises. However, in order to establish a measure for determining enduring efficacy of the educational experience, data will be collected as part of the regular, annual delivery of the course. Numerous existing approaches are available (see for example [5, 8, 14, 17, and 23].) Given the subjective nature of what is being taught, we plan on establishing a follow-up vehicle to track the students that pass through the courses over the interval of three to five years. Such a systematic vehicle will provide evidence to:

- develop an understanding of how elements of the graduate experience impacts participants and enhances the effectiveness of such programs (understanding);
- improve program activities, processes and outcomes in successive cohorts (improvement);
- and render judgment about the overall merit or worth of the learning experience.for meeting the needs of students as they become workers facing ever-new ethical challenges in their workplaces.

The overarching questions that guide the evaluation of the project are: "What long-term impact does participation in the graduate engineering ethics course or the faculty training course have on students' ability to make informed, ethical decisions in both the academic and industrial setting?" and "How have activities and the structure of the engineering ethics project increased the number of students successfully trained in and using ethical methodologies in their work?

Another ancillary but significant target of our assessment is faculty, in particular assessing the extent that they use the program; their faithfulness to the model; and their feelings about barriers and enablers. Faculty who attend workshops and training will also be tracked over time to assess the changes in their attitudes and approaches to teaching ethics in their courses.

Again, we want to be clear that formative evaluation measures will be used to determine students' progress on an ongoing basis. A summative evaluation will be administered at the end of each course by accumulating overall data from a variety of sources which could include pre- and post- tests, focus group and/or individual interviews, and journals/portfolios. Quantitative and qualitative data analysis will identify evidence of positive effects on students' abilities to make informed ethical decisions and positive effects on faculty members' abilities to train students at the graduate level in these areas. Specifically, we will create:

A student questionnaire that is designed to systematically gather student self-ratings of their skills and knowledge level in a field of interest and knowledge and skills needed to make ethical decisions or to teach ethics in the context of engineering and technology.

We also intend to develop a formative evaluation instrument that compares the approach to "best practice" [8, 23]. This is intended to determine how well the program is meeting objectives related to student participation and program quality.

A proposal has been submitted to UTEP's Institutional Review Board to ensure proper protocols are followed during this research.

VI. Conclusions and Future Work

The need to address the ethical implications of scientific, engineering, and technological advances is ongoing and will continue to increase exponentially as the impacts of these advances continues to determine the conditions of the interrelated spheres of academia, industry, and social life. Therefore, the need for improved training in ethics and a greater consideration of the consequences of personal choices in shaping professional actions will also continue to grow. The fellows and associates involved in ISTEP are developing pedagogical programs linked with relevant research intitatives in order to design more dynamic (and less mechanical) techniques for enabling faculty to better prepare students and each other for a future that will require the ability to reason about and impact policy decisions that cross socio-political boundaries. Teaching graduate students in engineering, who will become the academics, professionals, and policy makers in the future, to better understand and to apply ethical reasoning in their professional settings is one step in that development.

mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

An Empirical Study of Potential Vulnerability Faults in Java Open-Source Software

Steve Counsell and Stephen Swift
School of Information Systems, Computing and Mathematics,
Brunel University, Uxbridge, Middlesex. UB8 3PH.
{Steve.Counsell and Stephen.Swift}@brunel.ac.uk

Abstract. Program code that has been identified as vulnerable to malicious attack, irrespective of the system application domain, should receive a high level of developer 'fix' attention. In this paper, we present an empirical study of potential faults (or *p-faults*) attributed to code vulnerability in ten Java Open-Source Systems (OSS). The study used a tool to extract six different categories of potential and common fault embracing: code vulnerability, (lack of) program correctness, bad practice, multi-threaded correctness, questionable practice and performance. Two research questions were then investigated. Firstly, what patterns existed in the types of code vulnerability p-faults found in the ten systems? Secondly, were those p-faults related in any sense to the other types of p-fault identified by the tool? Results showed a high percentage of classes with vulnerability p-faults to contain no other forms of fault. However, a strong association between p-faults in the 'bad practice' category and vulnerability p-faults was observed in the remaining classes, suggesting the two categories may have a level of inter-dependence.

I. INTRODUCTION

For an Open-Source System (OSS), possibly downloaded thousands of times by different users, the problem of vulnerable code becomes magnified *n*-fold; OSSs have been the subject of much recent research interest [3, 14]. An equally important aspect of vulnerability faults is the extent to which they may be related to other types of fault. In this paper, we describe details of an empirical study that identified, using a tool, six sets of potential faults (or for brevity throughout *'p-faults'*) from ten Java Open-Source Systems. A key category of extracted p-faults related to code vulnerability and this formed the basis of our analysis. The study explored two key research questions. Firstly, we investigated the frequencies of the different types of p-faults in the code vulnerability category. Do some vulnerability p-faults generally occur more frequently than others? Secondly, we investigated whether the same vulnerability p-faults co-existed in classes with p-faults from the other five categories. From a maintenance perspective, this second question has significant resonance since one type of fault can often be the cause of other faults in the code.

II. RELATED WORK

A number of notable previous studies have investigated the relationship between program attributes and faults in code. Ostrand et al., [16] used binomial regression to predict which files in a large industrial inventory system were most likely to contain the largest numbers of faults. Graves et al., [9] considered the change history of a telecommunications system as an indicator of likely faults. Moller and Paulish [15] investigated the influence that size had on fault-density; 'large' modules tended to have lower fault densities than 'small' modules. In support of this work, Hatton [11] found that medium-sized modules tended to be more reliable than smaller modules. In the same vein, Basili and Perricone [1] observed that smaller Fortran components were likely to have greater fault density. In the past, work on defect models using Ada has also been investigated [5]. Khoshgoftaar et al., [13] worked on identification of fault-prone modules in a sub-system of an Attack Radar System; therein, discriminant analysis was used to predict whether each module in the next life cycle iteration would be considered fault-prone.

A number of criticisms of fault analysis research were highlighted by Fenton and Neill [6] including a description of inconsistencies over definitions of defect, error, fault and failure as well as use of the term 'module'. Gyimothy et al., [10] presented a number of hypotheses relating fault-proneness to the Chidamber and Kemerer (C&K) object-oriented metrics [4] using data for the Mozilla suite from sources including Bugzilla. They employed logistic and linear regression to relate metrics to number of bugs found, as well as machine learning to correlate faults to the metrics, and concluded that several metrics are useful

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 514–519.
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mmeybodi@aut.ac.ir

predictors of faults, the Coupling between Objects (CBO) metric of C&K being the best predictor.

III. DETAILS OF THE STUDY

Ten Java OSSs were used as a basis of our study and were chosen on the basis of a search in sourceforge.net for 'all Java systems'. Systems returned by that search were then examined in sequential order of appearance by a tool called FindBugs [7] for at least one vulnerability p-fault. The FindBugs tool analyses the Java bytecode for common fault patterns and is trademarked by the University of Maryland. It is freely available to download and according to the home pages of FindBugs, is widely used by companies and others (the home page states approximately 368, 000 users); it has also been the vehicle for academic research [12].

A. Categories of p-fault

The prime category of p-fault investigated in this paper is the vulnerability category; this category related to any code that posed a potential risk in terms of malicious attack. We describe the relevant types of p-fault throughout our analysis and Appendix A contains descriptions of vulnerability p-faults not described in the main body of the paper. The five categories (in addition to the vulnerability category) with quotes from [7] where appropriate are:

- Correctness: 'An apparent coding mistake resulting in code that was probably not what the developer intended.' Examples include field only ever set to null, method ignores return value and double assignment of field.
- Bad Practice: 'Violations of recommended and essential coding practice. Examples include hash code and equals problems, clone-able idiom, dropped exceptions, serializable problems, and misuse of finalize.'
- Multi-threaded: A potential fault due to careless housekeeping of threads. Examples include method does not release lock on all paths, unconditional wait and field not guarded against concurrent access.
- Questionable Practice: 'Code that is confusing, anomalous, or written in a way that leads itself to errors. Examples include dead local stores, switch fall through, unconfirmed casts and redundant null check of value known to be null.'
- Performance: Code written in such a way that would detract from the efficiency of the system. Examples include a private method never being called, an unread or unused field, and inappropriate use of String.

B. The Ten Java Systems

The source directories of approximately fifty systems were investigated in order to obtain the ten OSS systems used in this study (approximately 40 system contained no p-faults whatsoever). The ten systems, descriptions of which were taken from their entries in sourceforge.net, together with the total number of classes analyzed by FindBugs for each system were:

1. System 1: a Java Framework for developing learning systems (32 classes).
2. System 2: a forensics tool that creates a virtual machine out of a raw disk image (159 classes).
3. System 3: a Java test-bed for investigating situated multi-agent systems. The tool allows users to experiment with various aspects of multi-agent systems (649 classes).
4. System 4: a Java package featuring contextual information management, command line parsing and lexical information treatment (86 classes).
5. System 5: a grid computing Java toolkit to run applications in parallel (890 classes).
6. System 6: a work flow management system where business processes can be expressed in process archives using a simple language (784 classes).
7. System 7: an OO framework in Java for building Case-Based Reasoning systems (1253 classes).
8. System 8: a custom source generator written in Java which wraps AST syntax and is then placed into Velocity context (102 classes).
9. System 9: an interface engine and protocol translator for industrial control systems (82 classes).
10. System 10: a Java integrated development framework for creating intelligent and multi- agent Systems (914 classes).

IV. DATA ANALYSIS

Table 1 shows summary data for the number of each of the p-fault categories by system extracted by the tool: Vulnerability, Correctness, Bad Practice, Multi-threaded, Questionable Practice and Performance categories. The highest number of vulnerability p-faults occurred in System 7 and this system also exhibited the most p-faults in the Correctness and Bad Practice categories. System 10 featured the highest number of Questionable Practice (121) and Performance p-faults (516). These two systems also happened to be the largest of the ten systems (with 1253 and 914 classes, respectively).

mmeybodi@aut.ac.ir

Table 1. Summary of Bugs according to category

Sys.	Vuln.	Corr.	Bad Pract	Multi thread.	Quest. Pr.	Perf.	Tot.
1	17	1	0	0	2	0	20
2	4	0	4	0	1	3	12
3	35	7	32	3	27	31	135
4	6	0	2	0	0	3	11
5	41	6	17	16	24	49	153
6	36	5	42	9	10	19	121
7	58	8	128	0	27	76	297
8	6	4	0	0	121	0	131
9	4	3	2	0	2	3	14
10	30	7	77	4	136	516	770
Tot	237	41	304	32	350	700	1664

C. Vulnerability p-fault types

We first investigate the distribution of p-faults within the vulnerability category. In total, there are thirteen possible types of vulnerability p-fault that the FindBugs tool will attempt to extract. Figure 1a shows that occurrences of only five of the thirteen types of vulnerability p-fault were found across all ten systems (Appendix A contains descriptions of the other eight types in this category). The three identified types with quotes where appropriate from [7] were:

1. The **EI** p-fault, described as**:** Code 'may expose internal representation by returning reference to mutable object.'

   'Returning a reference to a mutable object value stored in one of the object's fields exposes the internal representation of the object. If instances are accessed by un-trusted code, and unchecked changes to the mutable object would compromise security or other important properties, you will need to do something different. Returning a new copy of the object is a better approach in many situations.'

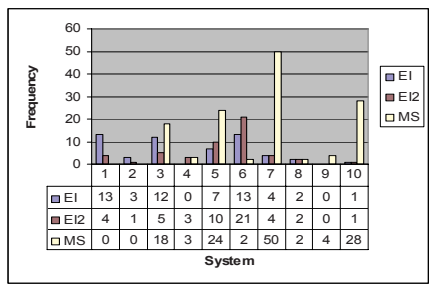
2. The **EI2** p-fault, described as: Code 'may expose internal representation by incorporating reference to mutable object.'

   'This code stores a reference to an externally mutable object into the internal representation of the object. If instances are accessed by un-trusted code, and unchecked changes to the mutable object would compromise security or other important properties, you will need to do something different. Storing a copy of the object is better approach in many situations.'

The third type of p-fault is called **MS** and, for convenience, we sub-categorize it into three further p-faults, described:

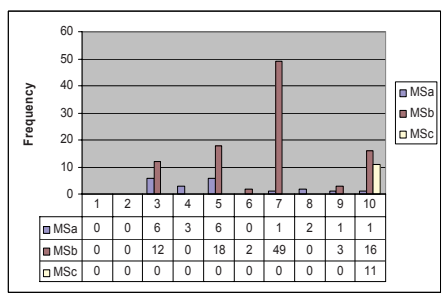
- MSa: A 'field should be (moved out of an interface) and made package protected. A mutable static field could be changed by malicious code or by accident. The field should be made package protected to avoid this vulnerability.'
- MSb: A 'field isn't final but should be. A mutable static field could be changed by malicious code or by accident from another package; the field should be made final to avoid this vulnerability.'
- MSc: A 'public static method may expose internal representation by returning array. A public static method returns a reference to an array that is part of the static state of the class. Any code that calls this method can freely modify the underlying array. One fix is to return a copy of the array.'

Fig 1a shows a strong bias towards the MS sub-category of p-faults amongst the total vulnerability p-faults extracted. Systems 3, 5, 7 and 10 are particularly noteworthy in this sense with 18, 24, 50 and 28 p-faults from this category. Fig 1b shows the breakdown of MS p-faults across the same ten systems.



	1	2	3	4	5	6	7	8	9	10
EI	13	3	12	0	7	13	4	2	0	1
EI2	4	1	5	3	10	21	4	2	0	1
MS	0	0	18	3	24	2	50	2	4	28

Fig. 1a. P-fault distribution



	1	2	3	4	5	6	7	8	9	10
MSa	0	0	6	3	6	0	1	2	1	1
MSb	0	0	12	0	18	2	49	0	3	16
MSc	0	0	0	0	0	0	0	0	0	11

Fig. 1b. Distribution of vulnerability p-faults

By far the most common p-fault is MSb with a peak of 49 occurrences in System 7. Only System 10 exhibits any MSc type p-faults whatsoever. Systems 3 and 5 also exhibit

mmeybodi@aut.ac.ir

relatively large numbers of MSb p-faults. Together with Systems 7 and 10, these four systems are the four largest. An interesting question (but outside the scope of this study) is whether the size of the system is the main contributor to the number of p-faults or that each of these four systems had evolved to a greater extent and are starting to show the signs of decay.

D. P-fault Analysis

An initial question that arises is whether, for each of the 237 vulnerability p-faults identified, we can find any evidence of relationships with other p-fault categories. In other words, when a vulnerability p-fault is identified by the tool, is it likely that there will also be p-faults from other categories? To investigate this question, we first view the relationship on a class basis and then extend the analysis to a package basis.

Class-based Analysis. Fig 2 shows, for each system, the number of classes where at least one p-fault was identified by the tool. It also shows the number of classes where: at least one vulnerability p-fault was found *and* at least one p-fault from another category was also identified (henceforth, we will refer to this combined group as 'mixed p-fault' classes).

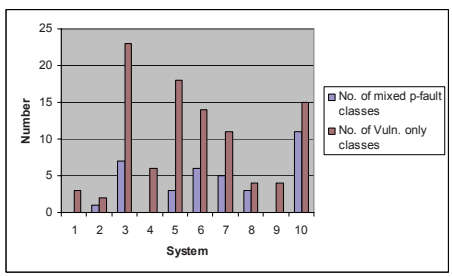


Fig. 2. Mix of vulnerability p-faults and other p-faults

The data for this figure is shown in Table 2. The system with the highest number of mixed p-fault classes is System 10 although not when expressed as a percentage of the total number of classes examined; Systems 1, 4 and 9 have zero mixed p-fault classes.

Table 2. Classes with at least one p-fault/mixed p-faults

System	Classes >= 1 p-fault	Classes >= 1 Vuln. p-fault	Mixed p-fault classes
System 1	5	3 (60%)	0 (0%)
System 2	4	2 (50%)	1 (25%)
System 3	58	23 (39.65%)	6 (10.34%)
System 4	9	6 (66.67%)	0 (0%)
System 5	86	18 (20.93%)	2 (2.33%)
System 6	74	14 (18.92%)	6 (8.10%)
System 7	164	11 (6.70%)	6 (3.66%)
System 8	4	4 (100%)	3 (75%)
System 9	12	4 (33.33%)	0 (0%)
System 10	199	15 (7.50%)	11 (5.53%)
Total	615	100	35

One noticeable feature from Table 2 is that for some of the systems, a high percentage of classes with a p-fault are also classes with a vulnerability p-fault. For example, 39.65% of all classes in System 3 with at least one p-fault also contain a vulnerability p-fault; for System 6, nearly 1 in 5 of classes with a p-fault also contains a vulnerability p-fault. However, the number of classes where they appear with other types of p-fault appears significantly less (column 4). Only 35 of the 100 classes containing a vulnerability p-fault also contain a p-fault from another category. For three of the systems (1, 4 and 9) there are no mixed p-fault classes.

Correlation analysis. Table 3 shows the correlation between the number of vulnerability p-faults (x) and the number of other types of p-faults (from any category) when at least one vulnerability p-fault is present (y). We have used Pearson's (a parametric test) and Kendall's and Spearman's (both non-parametric tests) to illustrate the strength and direction of the correlation.

Row 1 of Table 3 shows the correlation values when all pairs of x and y are included. Of the 100 classes where there was at least one vulnerability p-fault, 65 classes contained vulnerability p-faults only. Row 2 of Table 3 shows only a slight increase in the negative correlation (this row represents the same correlation values but with zero-valued rows in y removed). There is small negative correlation shown for each of the three coefficients in row 1 and row 2 suggesting that there tend to be fewer p-faults from other categories when a vulnerability p-fault was identified by the tool. In fact, only 288 p-faults of the total 1427 p-faults in the other five categories were associated with any vulnerability p-faults. Moreover, 6 classes accounted for 195 of those 288 p-faults (one class actually comprised 116 p-faults from other categories).

Both of these statistics illustrate the limited number of p-faults from other categories associated with vulnerability p-faults.

mmeybodi@aut.ac.ir

Table 3. Correlation vulnerability p-faults vs. other p-faults

Coefficient	Pearson's	Kendall's	Spearman's	Sample
Zero values included	-0.05	-0.07	-0.08	100
No. Zero values	-010	-0.12	-0.15	100

The prior data analysis and correlation values suggest that a vulnerability p-fault will tend to be associated with relatively fewer p-faults from other categories in a class where it is identified. Vulnerability p-faults appear to be largely isolated and independent of any other p-fault categories. The question that then arises is whether there is a trend (when they do occur) in the other p-fault types associated with vulnerability p-faults? To investigate this feature, we analyzed the p-fault data for every occasion where there was mixed-fault (i.e., in 35 occurrences). Of those 35 occurrences, the 6 most common types of p-fault identified were as follows in order of popularity (we note that p-faults 5 and 6 are tied). We also use the descriptions given by the tool and remark that some of these p-faults have multiple definitions relating to a particular theme, in which case we give an example description:

1. Category: **Correctness**; p-fault name: DLS: overwritten increment. Description: 'The code performs an increment operation (e.g., i++) and then immediately overwrites it. For example, i = i++ immediately overwrites the incremented value with the original value.'
2. Category: **Bad Practice**; p-fault name: Dm. Example Description: 'A method invokes: System.exit(...) which shuts down the entire Java virtual machine. This should only been done when it is appropriate. Such calls make it hard or impossible for code to be invoked by other code. Consider throwing a run-time exception instead.'
3. Category: **Bad Practice**; p-fault name: Se. Example Description: 'This serializable class defines a non-primitive instance field which is neither transient, serializable, or `Object`, and does not appear to implement the `Externalizable` interface or the `readObject()` and `writeObject()` methods. Objects of this class will not be de-serialized correctly if a non-serializable object is stored in this field.'
4. Category: **Performance**; p-fault name: SS: unread field. Description: 'Should this field be static? This class contains an instance final field that is initialized to a compile-time static value. Consider making the field static.'
5. Category: **Correctness**; p-fault name: ICAST. Example Description: 'This code converts an int value to a double precision floating point number and then passes the result to the Math.ceil() function, which rounds a double to the next higher integer value. This operation should always be a no-op, since the converting an integer to a double should give a number with no fractional part.'
6. Category: **Performance**; p-fault name: Bx. Example Description: 'A primitive is boxed, and then immediately unboxed. This probably is due to a manual boxing in a place where an unboxed value is required, thus forcing the compiler to immediately undue the work of the boxing'.

It is interesting that p-faults 1, 3, 4, 5 and (possibly) p-fault 6 in this list all relate to p-faults associated with the manipulation of fields. This corresponds with the themes of MSa and MSb categories of p-fault identified in Figure 1b, both of which relate to fields (and of which many were identified by the tool). We could thus hypothesize that vulnerability p-faults have a strong symbiosis with p-faults identified from these five frequent p-faults. This was a surprising result from the data analysis and provides us with an insight into possible relationships that vulnerability p-faults may have with other categories of p-fault. Categorizing the same data into the number of classes in which mixed p-faults appeared, we obtain *exactly* the same top three. In other words, the DLS, Dm and Se p-faults appear most frequently with vulnerability p-faults (and in absolute number also). The 'Bad Practice' p-fault category thus accounts for the second and third top categories linked to a vulnerability p-fault. In fact, were it not for the 114 DLS p-faults attributable to a single class in System 8, the Bad Practice category would account for the first and third related categories linked to vulnerability p-faults.

It is also remarkable that the performance category has the highest number of p-faults across all ten systems (i.e., 700), but does not seem to figure prominently in classes with a vulnerability p-fault. Inspection of the raw data revealed that many of the performance p-faults tended to cluster in large amounts in a relatively small number of classes. One hypothesis for this phenomenon is that a single performance p-fault may permeate through a large section of code in a class, especially if that performance p-fault is related to a data structure used throughout the class. Elimination of the initial offending code might also cause other performance p-faults to be eliminated also. Finally, notable for its absence in our analysis is the 'Questionable Practice' category. No occurrences of p-faults in this category were associated with vulnerability p-faults. One suggestion for this feature of the analysis is that the

mmeybodi@aut.ac.ir

characteristics of vulnerability p-faults are such that they may induce identifiable bad practice, but not questionable practice. The multi-threaded category of p-fault also seems to have played very little part in the analysis; this may be simply due to the relatively small numbers of p-faults in this category and/or that the developers simply did not use multi-threading features.

V. CONCLUSIONS

In this paper, we described an empirical study investigating the trends in potential vulnerability faults in ten, Java OSSs. A tool called FindBugs was used to extract the data using the static source classes. Results from the study showed a high percentage of classes with potential vulnerability faults to contain no other forms of p-faults. This suggests that faults associated with code vulnerability tend to be isolated and independent. For classes where other types of fault were identified, a strong association between p-faults in the 'bad practice' category and vulnerability p-faults was observed. This implies the two categories may have a level of symbiosis (or inter-dependence). In terms of a broader picture, the analysis described could inform our understanding of developer tendencies, habits, language features and finally, fault patterns that pose the biggest threat to code security. One aspect of future work that we are particularly keen to investigate is the potential for refactoring [8] in response to identified code trends. The FindBugs tool does offer some advice in terms of refactoring as a remedy to certain fault patterns, and we feel that other types of p-fault could also be used to inform refactoring of the underlying Java source code.

APPENDIX A – Eight (of fifteen) other vulnerability p-fault descriptions taken from [7]

1. FI: Finalizer should be protected, not public
2. MS: May expose internal static state by storing a mutable object into a static field
3. MS: Field isn't final and can't be protected from malicious code
4. MS: Field should be both final and package protected
5. MS: Field is a mutable array
6. MS: Field is a mutable Hashtable
7. MS: Field should be package protected
8. DC: Possible double check of field

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mmeybodi@aut.ac.ir

An Analysis of Faulty and Fault-Free C++ Classes Using an Object-Oriented Metrics Suite

S. Counsell,
Department of Information Systems and Computing, Brunel University,
Uxbridge, Middlesex. UB8 3PH.
Email: steve.counsell@brunel.ac.uk

Abstract - In this paper, we analyze a dataset freely provided through the PROMISE repository containing data on object-oriented (OO) class features and associated faults. We used a set of metrics provided with the dataset, based loosely on the Chidamber & Kemerer (C&K) metrics for our analysis; in particular, we compared and contrasted the characteristics of classes containing faults with those containing zero faults as a mechanism for establishing their causes and a hypothesis-based approach was adopted to this end. Several key results emerged from our analysis. Firstly, coupling seems to be a key factor influencing fault-proneness; the likelihood of at least one fault is greater when there is relatively high coupling. Secondly, class size 'does matter' - the more methods in a class, the more faults the class tends to contain. Finally, cross-correlation of the five metrics revealed an interesting trait related to inheritance and a previous study into C++ friends.

I. INTRODUCTION

Faults continue to be an omnipresent feature of software. Although we can never guarantee the absence of faults from software, a constant motivation for developers is to produce software that is both robust and relatively fault-free. Yet our knowledge of faults and features of the OO paradigm that promote fault-proneness is very limited. In this paper, we analyze a dataset provided as part of the PROMISE repository [19]. The datasets in the PROMISE repository are donated freely by software engineers for further replication and analysis by researchers and practitioners. In this paper, we analyzed a dataset containing metrics collected from a large NASA C++ ground system of approximately forty thousand source lines of code. We partitioned the dataset into classes containing at least one fault and classes containing zero faults as a basis for our analysis. We adopted five of the NASA-defined class-based OO metrics [19] (all five of these metrics are very similar to five of the six metrics proposed by Chidamber & Kemerer (C&K) [7]); again the metrics data was freely provided as part of the PROMISE repository. Our analysis revealed some interesting results. Firstly, coupling was found to be a key factor influencing fault-proneness; the likelihood of at least one fault occurring in a class is significantly greater when there is relatively high coupling. Secondly, class size does seem to be an important factor in fault distribution and occurrence. The higher the number of methods in a class, the more faults the class is likely to contain. The results also confirmed an earlier analysis of the use of friends in C++ software where relatively high coupling was found to occur at deep levels of the inheritance hierarchy [10].

II. RELATED WORK

In terms of related work, the NASA dataset used for this study was donated by A. Koru and was used in an investigation of defect prediction based on module size [16]; in total, five NASA systems were used as a basis of their study. Their results suggested that using class-level data provided better predictive performance than that at the method level and also that quality assurance is better guided when defect prediction is performed on data relating to larger modules. The seminal paper by C&K that describe their metrics [7] detail empirical analyses of systems at two sites, one of which used C++ and the other Smalltalk. While the authors conclude that their metrics do offer insights into whether developers are following object-oriented principles, it is also noted that the extent of inheritance at both sites was small. In Basili et al., [3], the C&K metrics were used as predictors of fault-prone classes. Data from eight medium-sized management systems, developed in C++ was collected. An experimental hypothesis suggested that a class located deep in the inheritance hierarchy was more fault-prone than a class higher up in the hierarchy; this hypothesis was found to be supported with statistical significance. Finally, the use of software metrics [14] for analyzing fault trends in classes can inform out knowledge of

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 520–525.
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mmeybodi@aut.ac.ir

software quality and point to areas in a system needing attention [1, 6, 17].

III. METRICS ANALYZED

Five of the NASA-defined OO metrics were used in this analysis [18]:

1. Coupling Between Objects (CBO). This metric measures the distinct number of associations between a class and other classes, but excludes inheritance-based coupling. This is similar to the CBO metric of C&K by the same name.
2. Depth of Inheritance of a class (DIT). This metric measures the position of a class in an inheritance hierarchy. The root of an inheritance hierarchy has DIT value one, and any immediate descendents DIT value two, the classes below that value three etc. This is similar to the C&K DIT metric of the same name.
3. Lack of Cohesion of the Methods of a class (LOCM). The definition of the LOCM metric taken from [22] is: 'for each data field in a class, the percentage of the methods in the class using that data field; the percentages are averaged then subtracted from 100%. This metric is very similar to the Lack of Cohesion of the Methods in a Class (LCOM) of C&K.
4. Number of Children (NOC). This metric measures the number of immediate children belonging to a class. Unlike DIT, it is a measure of the span of the inheritance hierarchy rather than its height (this metric is identical to the C&K NOC metric of the same name).
5. Weighted Methods per Class (WMC). This metric is defined as the number of public, private and protected methods in a class. The metric is identical to the WMC metric of C&K. The 'weighted' qualifier originally meant as a complexity value is widely acknowledged to be '1' for all methods.

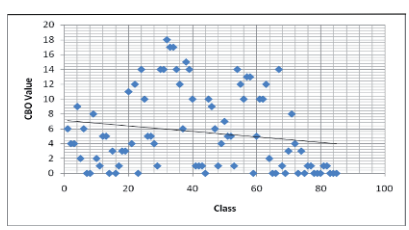
Henceforward, we define a 'fault' in an identical fashion to that of Koru and Liu [16], as 'a change needed in a software module because of a problem or a combination of related problems in software'.

IV. DATA ANALYSIS

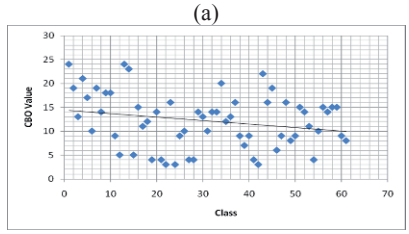
In total, the PROMISE dataset comprised data on 146 C++ classes. For our study, the dataset was partitioned into two distinct sets. Firstly, classes with zero observed faults and secondly, classes with at least one attributed and observed fault. For each of the metrics, we compared the set of 85 classes without faults with the 61 classes with at least one fault. The distribution of faults in the 61 classes gave rise to a maximum number of faults of 101, a mean number of faults 10.97, a median number of faults of 6 and a standard deviation of 14.56. For each of the analyses, we propose a hypothesis based on current 'understanding' about the class feature being analyzed and its relationship with faults.

A. Coupling between objects

Hypothesis-CBO: *High levels of coupling cause more faults than low levels of coupling. This hypothesis is based on the premise that if a class has a large amount of coupling, then the opportunity for faults to be invested in that class due its complexity and through consequent side-effects is greater. If a class has low levels of coupling, then the functionality of the class is much easier to determine, its complexity less and the possibility of faults being invested correspondingly lower.* Too much coupling is widely recognized as harmful - every developer should seek to minimize coupling and maximize cohesion in their code. The scatter plot in Fig. 1a shows the distribution and trend line of CBO values for classes containing zero faults. Correspondingly, Fig. 1b shows the same for CBO values for classes containing at least one fault. There is a clear tendency for classes containing faults to contain more coupling. The mean value of observations from Fig. 1a is 5.5 and that from Fig. 1b, 12.14. In other words, classes with at least one fault contain, on average, more than twice as much coupling as classes without faults. Remarkably, the median CBO value from Fig. 1a is 4 and for Fig. 1b is 13, further illustrating the difference between the two sets of data.



(a)



(b)

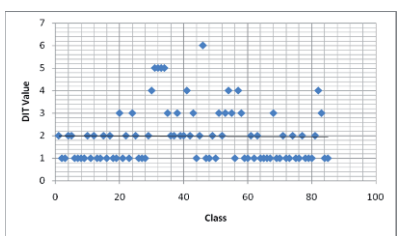
Fig. 1a: CBO values for zero-fault classes; 1b: CBO values for classes containing at least one fault

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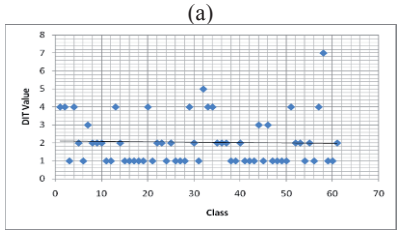
The correlation relationship between CBO and faults is not particularly striking; for Fig. 1b the Pearson correlation coefficient (a parametric test) is just 0.22 and Spearman's Rank correlation coefficient (non-parametric test) is 0.37 (significant at the 5% level). While we cannot necessarily claim with any conviction that the more coupling in a class, the more faults, we *can* however state that we believe that a class containing at least one fault is likely to contain higher coupling than a class without faults (we could not have drawn this conclusion unless we had examined the zero-fault classes). This result is in keeping with much of the stated literature on the harmful effects of coupling [4, 5]; the lack of a high positive correlation also highlights the importance of coupling 'grading': one form of coupling may induce more faults than other, less harmful forms.

B. Depth of inheritance

Hypothesis-DIT: *Classes with a high value for DIT are more fault-prone than classes with a low DIT value. This hypothesis is based on the premise that classes low down in the inheritance hierarchy need to appreciate the functionality and dependencies of classes above in order to reap the benefits of inheritance* (*they inherit superclass features*)*. This adds complexity to an understanding of the inheriting class.* Fig. 2a shows the DIT values for classes with zero faults and Fig. 2b for classes with at least one fault. The mean value for DIT from Fig. 2a is 1.96 and for Fig. 2b, 2.03. This statistic suggests that, contrary to the hypothesis stated, there does not seem to be a marked difference between the DIT values for classes with zero faults and those with at least one fault.



(a)



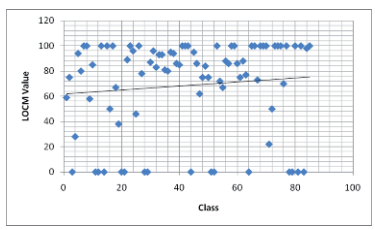
(b)

Fig. 2a: DIT values for classes with zero faults; 2b DIT values for classes with at least one fault

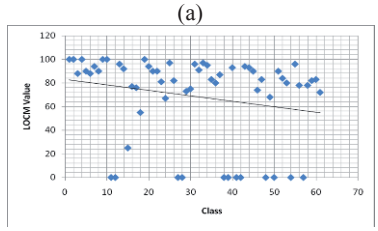
The correlation relationship between DIT and faults is striking for the lack of any correlation; the Pearson correlation coefficient is actually just 0.04 and Spearman's 0.15, further suggesting that the DIT is not a particularly good indicator of the presence or absence of faults in a class. This is an interesting result, since a range of previous studies (including those by the authors) have claimed that inheritance is an impediment to maintainability and that flat systems, with no inheritance, are easier to understand and modify [11, 15]. Both of these studies proposed that inheritance is more difficult to understand than if inheritance had been omitted altogether and we would have expected the correlation to be more positive. The median DIT from Fig. 2b is just 2, indicating a relatively shallow inheritance hierarchy anyway; deeper levels of inheritance are perhaps where problems with its use arise.

C. Lack of Cohesion in the Methods of Class

Hypothesis-LOCM: *Classes with a high value for LOCM are more fault-prone than classes with a low LOCM value. This hypothesis is based on the premise that classes with a high lack of cohesion will be difficult to understand and modify; equally, a class with a low LOCM will be easier to understand and modify – such a class is less likely to include faults as a result.* Fig. 3a shows the distribution of LOCM values for the set of classes with zero faults; Fig. 3b shows the distribution of LOCM for classes containing at least one fault. The mean LOCM for the values shown in Fig. 3a is 68.76 and for the values in Fig. 3b, that of 86. This suggests that classes with at least one fault tend to be less cohesive than classes with zero faults according to the LOCM metric and, in such a case, our hypothesis would be supported.



(a)



(b)

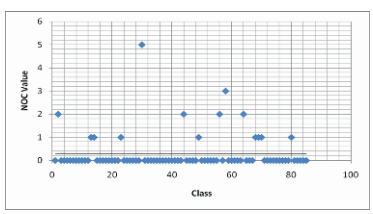
Fig. 3a: LOCM values for classes with zero faults; 3b LOCM values for classes with at least one fault

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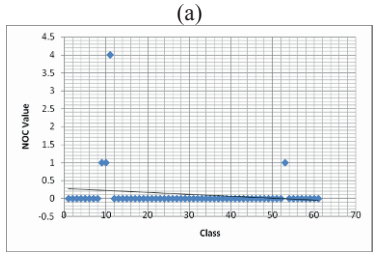
The Pearson correlation coefficient between LOCM and number of faults is 0.23 and for Spearman's it is 0.25, suggesting that a high LOCM is not necessarily associated with a high number of faults (neither value is significant). While anecdotal evidence would suggest that low cohesion is associated with high fault-proneness and vice versa, problems with a generally accepted definition of cohesion and the very subjective nature of the cohesion concept have caused interpretation difficulties in the past [8, 9]. No generally accepted definition of OO cohesion has yet been proposed and we could attribute the lack of correlation to this problem.

D. Number of Children for a Class

Hypothesis-NOC: *Classes with a high value for NOC are less fault-prone than classes with a low NOC value. This hypothesis is based on the premise that classes with a high number of children have dependencies beneath them* (*the opposite to DIT*)*. As such, these parent classes will be easier to understand since the developer does not necessarily have to understand the children classes in order to make a change in the parent class.* Fig. 4a shows the NOC values for classes with zero faults and Fig. 4b the distribution of NOC values for classes with at least one fault. The mean value from Fig. 4a is 0.28 and that for Fig. 4b, 0.11. Visual inspection of the two scatter plots suggests that classes with zero faults do tend to have a higher number of non-zero NOC values. Only 4 of the 61 values from Fig. 4b have a non-zero NOC value (6.56%), compared with 14 of the 85 values from Fig. 4a (16.47%). This relatively high proportion in the latter case is evidence in support of the stated hypothesis.



(a)



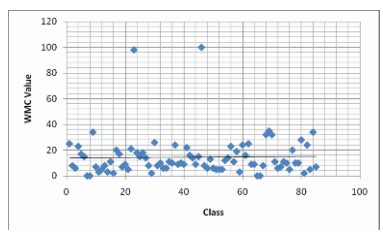
(b)

Fig. 4a: NOC values for classes with zero faults; 4b: NOC values for classes with at least one fault

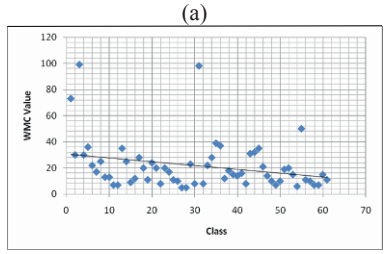
The Pearson correlation coefficient between NOC and faults is low and is, in fact, negative (-0.10); for Spearman's it is -0.22. As a metric, the usefulness of NOC has always been largely overshadowed by the DIT. In fact, the NOC metric has rarely reflected any meaningful, interpretable relationships. One suggestion for the lack of any insight using this metric may be that developers are uninterested in the width of an inheritance hierarchy and are more interested in class dependencies through the single linear relationship up or down the hierarchy (i.e., akin to the DIT metric). In other words, we suggest that an understanding of the functionality of a super class rather than a subclass is more in line with the changes a developer will typically make.

E. Weighted Methods per Class

Hypothesis-WMC: *Classes with a high value for WMC are more fault-prone than classes with a low WMC value. This hypothesis is based on the premise that classes with a relatively large number of methods will be difficult to understand and modify; equally, a class with a low WMC will be easier to understand and modify – such a class is less likely to include faults.* Fig. 5a shows the distribution of WMC values for the classes with zero faults; Fig. 5b shows the distribution of WMC for classes containing at least one fault. Visually, Fig. 5a indicates that a high proportion of classes have twenty or less methods. In fact, 67 of the 85 (79%) classes fell into this category. The same is not true of the values from Fig. 5b; only 40 of the 61 classes (66%) contained 20 or less methods. In keeping with the previous hypothesis, this seems a reasonably good argument in favor of the stated hypothesis.



(a)



(b)

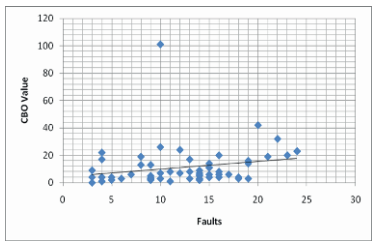
Fig. 5a: WMC values for classes with zero faults; 5b WMC for classes with at least one fault

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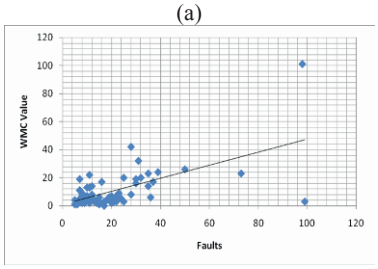
The Pearson correlation coefficient for WMC against faults is 0.60 (this value is significant at the 1% level) and for Spearman's it is 0.40 (also significant at the 1% level). In other words, the more methods in a class, the more faults the class is likely to contain. We thus find compelling evidence for the stated hypothesis. We conclude that small classes are less fault-prone than larger classes for the dataset under consideration. There is an equally interesting conclusion that could be made from this result. While we accept that we are only using data from one dataset, we could nonetheless postulate that an optimal class size may exist beyond which faults tend to start to arise [12, 13]. Inspection of the dataset revealed a tendency for classes with less than 20 methods to contain zero faults. If we look at the distribution for the dataset under study, 39 of the 61 classes with at least one fault, and with at least twenty methods, accounted for approximately 76% of the total number of faults (the remaining 22 classes accounted for less than 24% of the total number of faults).

V. CROSS-CORRELATION

The study in this paper raises a number of issues. Only from the CBO and WMC metrics were we able to draw any concrete conclusions. Fig. 6a and 6b show these two metrics plotted against faults.



(a)



(b)

Fig. 6a: Correlation of CBO versus No. faults; 6b: WMC versus No. Faults

While correlation of the metrics against faults themselves may reveal limited results, a cross-correlation between each of the metrics may sometimes reveal further relationships. Table 1 shows the Pearson and Spearman's correlation coefficients for each of the five metrics when correlated against each other for classes with no faults and those with faults (italicized). For example, 0.57 and 0.53 represent Pearson's and Spearman's coefficients for fault-free classes; 0.50 and 0.54 represent the same coefficients for faulty classes. Single asterisked (*) values represent significance at the 1% level and '**' represents significance at the 5% level (both two-tailed).

TABLE I. Cross-correlation between metrics for zero-fault and faulty classes (italicized)

Metric	**DIT**	**LOCM**	**NOC**	**WMC**	**Faults**
CBO	0.57*, 0.53* *0.50*, 0.54**	0.13, -0.17 *0.52*, 0.55*	0.06, -0.12 *-0.01, 0.09*	0.03, 0.23** *0.33*, 0.48**	*0.22, 0.37**
DIT		0.18, 0.10 *0.36*, 0.50**	0.11, -0.16 *-0.10, 0.06*	0.20, 0.18 *0.07, 0.30***	*0.04, 0.15*
LOCM			0.04, 0.12 *-0.17, 0.09*	0.28*, 0.33* *0.38*, 0.54**	*0.23, 0.25*
NOC				-0.13, -0.15 *0.18, 0.27***	*-0.10, -0.22*
WMC					*0.60** *0.40**

One interesting and notable feature from Table I is the significant positive relationship for all values between the CBO and DIT. Since the CBO metric does not count inheritance, this value suggests that classes deep in the inheritance hierarchy have relatively large amounts of non-inheritance based coupling. One explanation for this feature could be that, in keeping with the results from an earlier study on friend classes in C++ [10] (themselves a form of coupling), developers add features at deep levels of an inheritance hierarchy as a short-cut, convenient method for inheriting behavior of superclasses without needing to disrupt or change the inheritance hierarchy. The trade-off of course is the added complexity in the classes deep in the inheritance hierarchy which as the data for CBO suggests may be the cause of relatively higher faults. The significant correlation between LOCM and WMC is also interesting and suggests that large classes are uncohesive and smaller classes tend towards cohesiveness. Noticeable are the relatively low correlation values of NOC with all of the other metrics reinforcing its lack of insight into class features.

mmeybodi@aut.ac.ir

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we have analyzed a dataset containing information about faults in a C++ system. The dataset was freely available as part of the PROMISE repository. We partitioned the dataset into classes with zero observed faults and classes with at least one observed fault. Some key conclusions can be drawn from the study. Firstly, in keeping with other empirical studies, there is some evidence that coupling is a likely contributor to fault-proneness. Class size seems to be an important factor also; the larger the class (in terms of its number of methods), the higher likelihood of a fault being invested in that class. We also found possible support for an earlier study into friends in C++ software, suggesting that coupling in deep levels of an inheritance hierarchy is the most 'harmful' and fault-prone form of coupling. In terms of future work, we could extend this study to include a large number of other system features provided as part of the dataset, for example, in-depth of size measures such as lines-of-code, comment lines and blank lines as well as structural complexity issues.

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mmeybodi@aut.ac.ir

An Effective Construction of Computer Assisted Lesson Based on Interactive Multimedia Computer Assisted Instruction Theory (IMMCAI)

Assoc.Prof.Pairoj Trirathanakul, Assoc.Prof.Suwanna Sombunsukho, Asst.Prof.Suriyong Lertkulvanich
Department of Information and Technology, Faculty of Industrial Education and Technology
Asst.Prof.Nithi Buranajant
Department of Production Engineering, Faculty of Engineering
King Mongkut's University of Technology Thonburi,
126 Phracha-Uthit, Bangmod, Thung-Khru, Bangkok 10140, Thailand

***Abstract*-This research paper is to present an effective construction of computer assisted lesson based on Interaction Multimedia Computer Assisted Instruction theory (IMMCAI) which was invented by the School of Industrial Education and Technology of King Mongkut's University of Technology Thonburi. The theory has five major steps which are: 1) analysis 2) design 3) development 4) lesson development using computer program 5) quality evaluation and assessment of learners' achievement. In summary, adopting the IMMCAI theory to develop computer assisted lesson package enables the lesson capable of effective E-Learning instruction and enhances learning achievement in learners.**

I. INTRODUCTION

E-Learning is an educational evolution that has been jostling for its space in the educational system and is surging to the fore to be in place of traditional paradigms of training. It exploits the potential of modern technologies, such as the Internet, intranet, extranet, satellite, video tape, CD etc. to enrich instruction approach. Although, the word 'E-Learning' is interchangeably referred to broad area of learning context, for example distance learning, learning through website, virtual classroom, to name a few. It is observable that all of them developed with one thing in common that is to associate methodologies in teaching/learning with multimedia technologies. Kurtus (Kurtus, 2000) mentioned that E-Learning is an instruction approach that the subject matter is written in a lesson package and illustration may be integrated into CD-Rom and learners access to learning via the Intranet or the Internet network. E-Learning is also used to refer to many form of instruction approach such as Computer-Based Training (CBT) and Web-Based Training (WBT) and distance learning. Campbell (Campbell, 1999) defined E-Learning that it is the exploitation of the potential of the Internet technologies to construct high quality interactive education. People around the world have convenience of accessing to learning opportunity beyond time and place constraint. It opens life-long learning to people [1]. The tendency of learning nowadays increasingly embraces E-Leaning using the Internet technologies as a means of communication to facilitate dynamic interaction among instructor and learners. In the ultimate, learners will be able to access to learning opportunity anywhere and anytime beyond place and time. The significant constituent parts of learning through computer are consisted of a Learning Management System (or LMS), computer network used to enhance learning process, information in digital form called Digital Content which can be transcribed through either Intranet, Extranet or the Internet [2].

E-Learning is a general term encompassed a broader area of learning context. Generally, it is used to refer to any form of instruction that imparts information using collaborative electronic technologies such as computer, the Internet network, Intranet, Extranet, television, or satellite. The familiar learning/teaching approaches that information transmitted through technologies are Computer-Assisted Instruction, Web-Based Instruction, On-line Learning, and distance learning via Satellite system and Video On-Demand, which is not rather well-known nowadays. However, presently, mentioning E-leaning means learning subject matter or information that suitably designed for training and uses web technologies for transmitting content and uses Course Management System in managing administrative functions. Learners who take E-Learning are able to access to learning through on-line system and/or by using CD-Rom. Moreover, E-Learning disseminates information using Multimedia Technology and Interactive Technology combined into learning approaches. As a matter of fact, there are a lot of terms that give closed meaning, for example Distance Learning, Computer Based-Training (or CBT), Online Learning (learning through the Internet) and many others. However the meaning of E-Learning has little consensus but in general it is the learning activities that use collaborative technologies such as computer network in transmitting content and such technologies provide new mechanisms for interactive learning environment. (Sooner computer might not be necessary anymore.). The networks are either the Internet or LAN (to link small geographic area, for example, within school or university) or WAN (to link broader area of communication such as in large organization or company).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 526–531.
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mmeybodi@aut.ac.ir

Advantages to E-Learning

The major advantages of E-Learning are flexibility and convenience because it supports learners and instructors' learning/teaching opportunity and requirements without place and time boundaries. Its flexibility enables learners to easily access to learning using whichever web browsing from whichever computer unit. Nowadays, accessing to the Internet is easier than before because the ICT infrastructure is more accommodating and sustainable than the past especially in big cities. As learners are able to access to E-learning easily, the cost in dispersing and receiving information is rather economical. And it is easy to update information because the system allows database producer to access server anytime from anywhere in the world. Therefore, at any time, from anywhere updating data can be done in time before any inundation damage occurred. This saves both time and expenses. Learners can learn at any time of day that is convenient for them without having to travel further than the nearest computer that saves much traveling hours. There was a report on "Return on Investment and Multimedia Training" said that training system that used computer network consumes only 50% of time that spent in training by trainer [2].

With the tremendous potential and the usefulness of E-Learning as described above, developing computer assisted lesson is the first priority in order to facilitate such an autonomous learning. This research is to present the process of developing an interactive multimedia computer instruction package which adopting the IMMCAI theory invented and created by the School of Industrial Education and Technology of King Mongkut's University of Technology Thonburi.

IMMCAI (Interactive Multimedia Computer Assisted Instruction) Interactive multimedia is a collection of technologies that have been joined together. With its synthesis of all the features, the previously dumb, mute and passive computers have become smart, talkative, and interactive. These are essential for feasible CAI applications, especially in respect of language teaching/learning that involve speaking, question-and-answer and other forms of idea communication interactivities. To our satisfaction, hi-fi digital sound and logical judgment as well as the animated content display afford us the cozy conditions in which the sequence of language teaching/learning processes can be carried out as we desire. The graphic and animation features can also greatly enhance teaching/learning in the aspects of pronunciation and calligraphy practice, among other things. With a little computer literacy and necessary training in package making, teachers themselves can design instructional materials for use with computers. This is no longer a laborious task. On the contrary, it can greatly reduce teachers, workload (examination packages, for instance, for automatic examination paper processing). Because of IMMCAI's hypertext features, computer instruction materials are no longer the run-of-mill stuff that in the past forces a linear, lockstep control of the learning process on the part of learners.

As can be seen in the efforts in individually feasible CAI, or rather IMMCAI, use on microcomputers could only be made meaningful after the breakthrough and development of computer hardware and software have attained such a level that IMMCAI programming or authoring is possible and practical on the user interface.

II. Procedures

An Effective Construction of Computer Assisted Lesson Based on Interaction Multimedia Computer Assisted Instruction Theory (IMMCAI) developed by the School of Industrial Education and Technology of King Mongkut's University of Technology Thonburi as follows [3], [4]. Topic selection, Analysis, Design, Development, Implementation, Evaluation, Publication, Follow-up.

Starting from Analysis, the following 16 specific steps are recognized :

Analysis

1. Brainstorm chart drafting
2. Concept chart drafting
3. Context network chart drafting

Design

4. Strategic presentation plan vs. behavior objectives and course flow chart drafting
5. Module presentation chart drafting

Development (Courseware forming)

6. Script development (Interactive subject frames)
7. Storyboard development
8. Content correctness check-up (Content validity and Reliability)
9. Text item check-up

Implementation

10. Authoring software selection
11. Acquisition of readymade video and audio and other clip art
12. Completion of creating CAI software package.

Evaluation

13. Quality evaluation
14. Small group rehearsal testing
15. Efficiency evaluation (Post-test, Ore-test) and effectiveness evaluation (E_{post}/E_{pre})
16. Preparation of user's manual for publication

A detailed discussion is provided below.

To select an appropriate topic for the IMMCAI software package development, we must identify the specific needs that must be satisfied through the implementation of the IMMCAI. They will be either supplement and enrich a classroom-teaching course or be used to replace formal classroom teaching courses in certain circumstances. Such factors will decide the type of IMMCAI module to be development to some extent: the drill and practice, tutorials, simulations or any other type. Following needs identification, the specific field and topic, target users, and educational level of the target users must also be considered. Therefore, concern is to be given to the following four aspects ;

1. The subject matter is comparatively stable and will last for a reasonably long duration to justify the effort and investment in development the package.

mmeybodi@aut.ac.ir

2. The subject matter integrated with IMMCAI constitutes a completely new field in which very few or no effort has been made so far.

3. The package produced is better than the conventional form in certain aspects for the subject matter teaching/learning and self-learning.

4. The selected field aha wide applicability; in other words, the finished package can be used by any number of users.

A. The First Step (Analysis)

Analysis has steps as follows.

1. Construct Brain Storm Chart. This refers to the approach to find out all the titles related to the general topic if the package chosen. When a project is decided and the topic chosen, the CAI designer and all other subject experts will meet in a brainstorming session to discuss and pool together whatever sub-titles are considered related to the general topic without questioning their content. Under certain sub-titles, there may be a lower level of sub-titles. It is essential, especially when the project is comparatively large and requires the participation of more than one person. The end result will be a brainstorm chart that visualizes the designer's thinking and provides convenience for the content designers at the following steps.

2. Construct Concept Chart. After analyzing content thoroughly, deleting, adding can be done as appropriate. It facilitates the forming or a complete idea about the IMMCAI module to be developed.

3. Construct Content Network Chart. In this process the structure for the CAI package is made to be presented in the form of a network chart, convenient for visualized analysis to determine if any part needs to be adds, deleted, corrected or changed.

B. The Second Step (Design)

Design has steps as follows.

4. Strategic presentation plan vs. behavior objectives and course flow chart drafting. Strategic presentation comprises the sequencing and timing of frame presentation, amount and type of explanations or hints and other kinds of coaching aid arrangements for presentation, as well as the strategic use of other reinforcements. Behavior objectives refer to the measurable goals of the instructional content specified in concrete behavioral terms. The target learner' knowledge level is estimated and is used for the reference in the design of package content specifically pointing to the area that needs to be addressed. After the comparison is made between the strategic presentation plan and the behavior objectives, a course flow chart cab be drafted for the use in the follow-up process of IMMCAI package development. The learning sequence of the package must be adjustable and adaptable to the special needs (self-learning, for instance) of the user. Furthermore, the creation of the IMMCAI package must be done in such a way that it can facilitate :

- More participation
- More freedom
- Less responsibility on the part of instructors
- Easier understanding
- Learning
- Maintenance of the learners' attention

5. Module presentation chart. Presentation of this processes is drafted in the form of modular blocks to indicated each of the specific functional parts of the design.

C. The Third Step (Development)

Development has steps as follows.

6. Script development. If all the previous preparatory and conceptual steps are finished, the IMMCAI development can proceed to the technical script drafting to establish actual teaching/learning content of the IMMCAI package that will form the input for the storyboard development. The implementation of this guided and controlled bv the previously established concepts and technical specifications, This step is very necessary and important especially when the project is quite large and in need of the pooled wisdom, teamwork, and cooperation to make it all-sided and complete. It also facilitates the supervising group's inspection and supervision. The script development should embody the overall use of the planned strategies and subject matter.

7. Storyboard development. With the completion of the script development, the storyboard development can be started to design the actual presentation frames. This step is to sketch the presentation of ideas on the topic so as to enable visualized, animated, and audible interactive illustration. They include (but may not be limited to) the optimized arrangement of the subject matter (text, graphics, narration, animations, etc.). the control functions (control key, prompt, hint, etc.), and display effects (color schemes, display transitions, animated text and graphic display pattern and size, etc.).

8. Content correctness examination. The storyboard development be subject to the content experts' inspection to examine its correctness, appropriateness and applicability. This so that its validity and reliability can be determined and the possible waste of resources be avoided before they have been actually inputted into computers for package processing. Among other thing, the focus of the inspection, of course, is upon the content of the subject matter.

9. Test item check-up. In this step, checking will be done on the test items so that the following four aspects can be tested :

- Difficulty level of the test items should meet the expected behavioral objectives designed against the target group's actual intellectual level.
- Discrimination of the test items means that the making of the test items should be able to promote the learner's understanding of the test items in a clearly distinguishable way without mixing up slightly different concepts and causing confusion.
- Validity refers to the appropriateness of the itemized content that are adopted for measuring the behavioral change entailed through the learning process by the target group (whether or not the adoption is acceptable and can be used).

mmeybodi@aut.ac.ir

- Reliability refers to whether the test items selected and adopted are excellent, good or poor in measuring the behavioral change of learners (degrees of accuracy).

If everything is found appropriate and acceptable in all these separated frames and modules, they can be together to form complete whole of a scripted courseware to finish the staged completion of the IMMCAI technical creation.

D. The Fourth Step (Implementation)

Carrying out the implementation stage using computer program has steps as follows.

10. Authoring software selection. With the completion of all the preparation for the creating of an IMMCAI software package on microcomputers, the attention of the investigator will be geared to selecting one of the authoring software programs available, with which the documented material will be processed and put into the form of an executable software package. There is a variety of authoring software readily available for IMMCAI package developers who may or may not have attained the command of programming languages. That is the reason why the CAI package development is called authoring instead of programming. Authoring software enables the making of a CAI package by the users who may not have learnt programming languages, and the basic and fundamental training in authoring software demands a minimum of time and effort on the part of users. To set up a complete IMMCAI software-processing environment, the following basic components should be obtained ;

- CAI executable file authoring software
- Special font (Thai, Chinese or other non-default needed)
- Graphic processing software
- Sound processing software
- Animation processing software

11. Acquisition of ready made video and audio and other clip art materials. It is not economical to start a project completely from scratch and build up an IMMCAI package out of nothing, There are many resources than can be used to speed up the creation process. By means of commercial purchases, access to database on the internet, and so on much ready-made material of texts , graphics, graphic designs, artistic patterns, pictures, sound effects, music and others can be made available for the use in the CAI creation. They can be integrated into the package directly (fully or partially).; they can be used a kind of raw material that, through some processing, will be turned into certain parts of the frames; and they can also be used as references and sources of provocative thought to give CAI creators enlightenment and inspiration (conceptually or technically). With the same hardware/software environment and the same finished script, individuals of different skills and attainments will create quite different finished products. This means that in the implementation phase, technical expertise and personal attainments are so important that they decide the quality of the CAI package.

12. Completion of CAI software creation. If all the hardware/software working environment, technical specifications and CAI script are well established, the CAI creation process can be started under the supervision of multimedia experts. To ensure smooth and successful creation, the following technical points must also be taken into consideration for the purpose of allowing smooth processing, optimizing the program structures, reducing the file size and safeguarding the processed data : a) selecting the operating system for the authoring software. b) the speed of the computer to be used for creating the CAI package. c) the capacity of the hard disk to be used for creating the CAI package. d) font selection for text display processing. e) image file type and image resolution selection for image file processing. f) audio quality selection for sound file processing. g) the use of transitions, other special effects and colors.

E. The Fifth Step (Evaluation)

Evaluating the quality of the lesson package and finding learning efficiency in learners has steps as follows.

13. Quality evaluation. The basic governing principles for quality evaluation should be that the finished IMMCAI package thoroughly express the original intention of its designers and fully present the subject matter of the script with which the IMMCAI package is created. The technical quality should at least be equal to (if not better than) current technological levels.

14. Small group rehearsal testing. With a comparatively large project, prior to the step 15 it is necessary to arrange a small group rehearsal testing to find out the best way to conduct the formal efficiency and effectiveness evaluation.

15. Efficiency Evaluation (E1/E2) and Effectiveness Evaluation (E_{post}-E_{pre}). These refer to the evaluations by means of the pre-test, trial use of the package created, post-test and comparison between the pre-test and post-teat results so that quantitative measurements of students performance and be obtained. The ratio of the stepped achievements to the total achievement made by learners shows the efficiency of the package content (E1/E2) and difference between the pre-test and post-test indicates its effectiveness (E_{post}-E_{pre}). In addition, it is also necessary to conduct a survey evaluation. Certain questionnaires can be created for the target students being tested and teachers to fill out. In an efficiency evaluation, the following formula will be used :

$E1/E2$ = Efficiency

Where

E1 represents the mean of the result obtained from the stepped tests (exercise questions used as test items under the control of the tester), namely :

$E1 = (E1_1 + E1_2 + E1_3 + \ldots E1_n)/n$

E2 represents the result obtained from the post-test.

Effectiveness evaluation is done through the use of the following formula :

E_{post}-E_{pre} = Effectiveness

Where

E_{post} represents the result obtained from the post-test.

E_{pre} represents the result obtained from the pre-test.

mmeybodi@aut.ac.ir

The difference between the pre-test and the post-test indicates the absolute value of knowledge gain of the students. As a supplementary measure, questionnaires of appropriate forms are also necessary and they will be used for conducting surveys on the garget students' and teachers' opinions about the acceptability of the package, However a more preferable approach of surveying is the direct personal interviews with the users (when possible) to avoid the irresponsible and misleading reaction on the part of some users that may occur in questionnaire survey.

16. Preparation of a user's manual. The ultimate purpose of creating an IMMCAI package is to distribute it among many targeted groups and have it used by them. If the evaluation results are found satisfactory and the package is suitable for publication, the user's menu must then be worked out. This provides the information to guide users on how to use the package, thus bringing to an end the IMMCAI package creation.

Publication

Before publication of a CAI software package, it is quite necessary to go through the legal procedure of obtaining a copyright for the package, in case the creator's intellectual property rights should be encroached.

Follow-up

The first publication of the package should be followed up with an actual test to be taken by all the users. Should the test be successful, there should be a strong demand for it. Then there will be the necessity to consider how to improve the second publication in due course, either by introducing new techniques or by improving the instructional content itself. The complete cycle of IMMCAI software package creation can therefore be signed off.

III. Summary

Application of interactive multimedia IMMCAI technology in the foreign language teaching/learning can be effective. To design and develop high quality programs as instructional research projects to be performed by students for finishing their theses, however, fist requires student language proficiency, comprehensive knowledge attainments, computer programming ability, creative thinking and artistic cultivation. It also needs supervisors' appropriate guidance, careful supervision and effective and timely control. Stress should be made upon the possible internal quality of the CAI package itself rather than the comparability with other ready-made commercial products.

One of the reasons why that the CAI products are looked down upon by many people who consider CAI a kind of children's toy may lie in the content quality of the CAI themselves. The lack of useful and meaningful content while making use of a lit of "interesting" superficial effects in some sense are the fatal traps that many CAI makers have fallen into. This has become and argument package needs to be made interesting things are only the means rather than the ends. If anyone really wants to have fun, there is no need to use such and instructional CAI. There are so may game software programs available that are far more funny.

It therefore can be seen that in CAI research more efforts should be made in respect to pedagogical philosophy, theory, methodology and technology for the purpose of raising the content quality. What we need choose to train are a kind of amphibian professionals who ate both competent in instruction and technology. Computer technologies, multimedia and hypermedia in especial, provide us the substantial means that will form the flesh and blood of the body, but what gives life to this body is nothing more than the intellectual knowledge and academic property/quality. CAI as the antecedent and functional part of Web Based Instruction and virtual universities, should focus on the development of pedagogy on the platform of the powerful modern computer technology achievements.

In an effective construction of computer assisted lesson based on Interaction Multimedia Computer Assisted Instruction theory (IMMCAI), we found that the lesson package possesses effectiveness that can be used in E-Learning effectively [5].

Example :

1. The computer assisted lesson package for Radiographic Testing subject which was developed using the Interactive Multimedia Computer Assisted Instruction theory (IMMCAI) was awarded Honorable Mention Prize in field of Information Technology and Public Communication from Invention Competition organized by Office of the National Research Commission of Thailand [6].

2. The multimedia development for website promoting thai herb learning was public Organised by IADIS International Association for Development of the Information Society, Co-Organised by The University of Dublin Trinity College, Dublin, Ireland. [7].

3. THE MULTIMEDIA DEVELOPMENT FOR THAI CULTURE EDUCATION CASE STUDY : A WEBSITE DEVELOPMENT FOR TEACHING THAI DESSERTS COOKING" was public International Conference "World Conference on Educational Multimedia, Hypermedia & Telecommunications" Organization by Lorenzo Cantoni Catherine McLoughlin, Lugano, Switzerland [8].



Fig. 1. Illustration of Main Page of computer assisted lesson package of Radiographic Testing subject

mmeybodi@aut.ac.ir

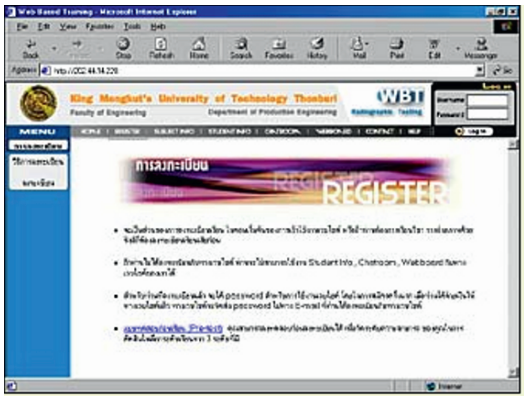


Fig. 2. Illustration of Register Page

IV. Discussion

From undertaking the research on developing computer assisted lesson package using the Interactive Multimedia Computer Instruction process (IMMCAI), we found that the process is very useful guideline for developing computer assisted lesson for E-Learning.

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mmeybodi@aut.ac.ir

Model of Structure of Personal Innovativeness in Education and Innovational Anxiety: Pilot Research Results

Svetlana Baigozina, E., M.Ed., trainer, A/S Datorzinibu centrs, www.dzc.lv,
4 Pulkveza Brieza str., Riga, LV-1010, Latvia, ph.+371 29176685, Svetlana.Baigozina@dzc.lv
Aivars Lasmanis, Ass.Prof., Latvian University, Faculty of Pedagogy and Psychology, http://www.ppf.lu.lv,
74/76 Jurmalas gatve str., Riga, LV-1029, Latvia, ph.+371 67033860, Aivars.Lasmanis@lu.lv
Eduard Saveliev, M.Psych., Zolitude Grammar School, www.zolitude.lv,
22 Ruses str., LV-1029, Riga, Latvia, ph.+371 67405913, Eduard.Saveliev@mail.ru
Talivaldis Mezis, M.Sc., IT Project manager, Riga City Council Education, Youth and Sports Department,
15 Kaniera str., Riga, LV-1063, Latvia, +371 67105958 Taivaldis.Mezis@ijsd.riga.lv
Irina Filipova, M.Psych., Zolitude Grammar School, www.zolitude.lv,
22 Ruses str., LV-1029, Riga, Latvia, ph.(+371)67405913, psirin@mail.ru

Abstract: Personal Innovational Anxiety, Metaprograms Polarization Model, Personal Innovativeness Structure Model.

I. Introduction

Implementation of any innovations, been these in education, management of the personnel or training in information technologies (IT), causes the necessity to consider the factor of each individual's willingness to accept innovations in professional or educational activity.

The questions considered in this paper are as follows:

- The attitude to innovations and to usage of innovations in professional activity and studying process;
- The analysis of subjective evaluations of innovations in education;
- Innovativeness and innovational anxiety of the subject of educational or professional activity;
- Parameters, structure and model of innovativeness of a personality;
- Model of interaction between The Leary Interpersonal 8-Circuit Model of Consciousness and innovativeness of a personality;
- Model of comparison and linear polarization of metaprograms and innovational anxiety;
- Interpretation of three-dimensional model of psychological and personal qualities of acceptance of innovations in the factorial analysis results.

Keywords: Innovational Anxiety©, Personal Innovativeness Structure Model©, Metaprograms Polarization Model©.

II. Definitions and Concepts

Personal Innovativeness in the Domain of Information Technologies (PIIT), by definition, is the willingness of an individual to accept or reject any kind of information technologies [1]. We shall define (in [2], [3]) a *Level of Personal Innovativeness* as a complex consisting of personal innovational anxiety, personal behavioral models and personal sociability-directed characteristics. This combination determines a degree of the personal attitude to any kind of innovations on a scale of innovational anxiety and simultaneously determines the formation of person's behavior in situations or in the particular environment, connected with the factors of innovational anxiety. As *Factors of Innovational Anxiety* we shall define the presence of the direct or indirect, direct or postponed necessity to use any innovations (for example, new methods of communication or computer technologies) within the framework of professional work, educational process, or in a local information environment. As *Local Information Environment* we shall define computers and computer networks (hardware), programs (software), electronic data used for learning process, a communication facility and the communications, users of environment (subjects), social components of the user's communications which are incorporated within the framework of local information technological system in local institution. The local information environment is a component of the global information space which provides opportunity to apply the information during professional or educational activities. In general *Local Information Environment* is a set of objects, subjects and conditions which provide means for professional or educational activity. Consequently, *Personal Innovational Anxiety* we shall define as a factor of speed and direction in a process of the person's development under new or changed conditions of a local information environment.

III. Theoretical Basis of Research

The list of psychological, cognitive, sociological and personal theories and models:

1. A Field Theory in Social Sciences and a Dynamic Theory of Personality (Kurt Lewin, 1935).
2. A Theory of Cognitive Dissonance (L.Festinger, 1957, [4]).
3. A Theory of Reasoned Action (Ajzen, Icek., & Fishbein, Martin, 1975, 1980, [5]).
4. An Innovation Diffusion Theory (Everett Rogers, 1983, [6]).
5. A Social Cognitive Theory (Albert Bandura, 1986, [7]).
6. A Dynamic Theory of Organizational Knowledge Creation (Nonaka I., 1994, [8]).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 532–537.
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7. The Interpersonal 8-Circuit Model of Consciousness, (Leary Timothy, 1958, [9]).
8. A Technology Acceptance Model (Bagozzi et al., 1992, Davis et al., 1989, [10]).
9. A Combined Technology Acceptance Model and Theory of Planning Behavior (Ajzen I.& Fishbein M., 1980, [5]).
10. A Professional Competence Model (Albert Bandura, 1993).
11. An Unified Theory of Acceptance and Use of Technology UTAUT (Venkatesh et al., 2003, [11]).

Last researches in nearest fields: see Ref. [14] - [26].

On the basis of the given theories and researches pilot-experiment and empirical research were organized and new models was created (see Appendixes).

IV. Description of All Stages of Empirical Research

A. The first pilot-stage, January 2005

- Creating of a questionnaire and questioning of 52 teacher-experts in education.
- Descriptive frequencies analysis and the content-analysis of answers.

B. Results and conclusions after the 1st stage

1. The attitude to IT innovations as a whole is positive.
2. Respondents explain existing problems by means of external reasons.
3. The results of the content-analysis of answers on possible problems in implementation of IT and ways of the decision: the opinion that the solution of problems depends on external factors prevail in respondent's sample. It means: a) significant displacement of the locus-control of respondents to an external parts of a locus-control scale, or b) the concrete level of anxiety of respondents.
4. Conclusion after 1st stage: respondents' anxiety might be personal, situational or it might be other anxiety caused by process: respondent's anxiety can be *innovational anxiety* at this moment of questioning - at the moment of active implementation of IT innovations in education [12].

C. The second stage, September 2005

- 27 respondents interviewing;
- The content-analysis of answers.

D. Results after the 2nd stage

1. The list from 96 parameters of willingness for usage of innovations was created.
2. The grouping of 96 parameters is carried out to classes. 16 classes of parameters are allocated and defined after a grouping.
3. Most and least frequently parameters mentioned by respondents are revealed.
4. Most and least significant for respondents parameters are revealed.
5. Comparison of results and the reasons was revealed and described.
6. The next hypothesis was putted forward: it could be that the respondents of the sample had given inadequate evaluation of a situation; or the variant of displacement of a problem of innovations is possible in this sample [13].

E. The allocated defined classes of parameters of innovations

Class 01 (psi) Parameters describing psychological features of a personality;
Class 02 (mer) Parameters of purposefulness;
Class 03 (kom) Parameters of communications;
Class 04 (prof) Parameters describing professional qualities;
Class 05 (pers) Parameters of personal features;
Class 06 (zin) Knowledge in new areas;
Class 07 (iem) Skills of using new technologies;
Class 08 (pra) Abilities to use new technologies;
Class 09 (arf) Parameters describing external influence;
Class 10 (arft) Parameters describing technical factors;
Class 11 (arfk) Parameters of the communications with experts;
Class 12 (att_prof) Parameters of professional development;
Class 13 (att_pers) Parameters of personal growth;
Class 14 (anx) Parameters of situational anxiety;
Class 15 (vel) Parameters describing desire to apply an innovation;
Class 16 (attieks) Parameters of the attitude to innovations [13].

F. The third stage, September 2005

- Questioning 16 respondents for finding-out 96 parameters evaluation on a 5-mark scale;
- The correlation and factorial analysis.

G. Results after the 3rd stage

1. There is no correlation between the subjective evaluations of parameters of willingness for usage of innovations with the age and the work experience of the respondents.
2. There is a weak significant correlation between subjective evaluation of some parameters with grade and area of education of the respondents.
3. There is a weak significant correlation of evaluation of all parameters between themselves [13].

H. Conclusions after the 3rd stage

2 components after factorial analysis are extracted (see Figure 1 and Table I): internal motivation of development of the person and possible innovativeness of a person.

I. Discussions after the 3rd stage

As a result of the previous pilot-researches stages and supervision over groups of respondents it is possible to formulate the following: The level of a person's acceptance of innovations is caused basically by the combination of psychological and communication qualities of the person, purposefulness of development of personality, instead of knowledge and skills [13].

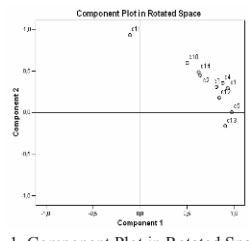


Fig. 1. Component Plot in Rotated Space: two components extracted after the 3rd stage.

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TABLE I
ROTATED COMPONENT MATRIX AFTER 3rd STAGE

	Component	
	1	2
pers_krit	.974	.006
psi_krit	.932	.293
atte_krit	.904	-.161
prof_krit	.877	.355
attp_krit	.840	.179
kom_krit	.813	.309
mer_krit	.639	.449
anx_krit	.623	.487
arfk_krit	-.111	.931
arft_krit	.500	.599

J. The fourth stage, October 2005 - December 2006

- Questioning 129 respondents for finding-out value judgment of 96 parameters on a 5-mark scale;
- The factorial analysis.

Results after the 4th stage

The level of a person's acceptance of innovations is caused basically by the combination of psychological and communication qualities of the person.

The level of person's acceptance of innovations is caused also by purposefulness of development of personal qualities.

A person's acceptance of innovations changes during professional or studying activities, it is possible to describe the direction, the speed, the acceleration of innovativeness.

Three components are extracted (see Table II, see three-dimensional model of components on Fig. 2, see two-dimensional projections of 3D model of Component Plot on Fig. 3, Fig. 4 and Fig. 5).

Below is a description of the dynamic process of acceptance of innovations in the personal development and socializing of a person.

K. Components in Pair №1: Speed of innovativeness of a person (IP) - a Direction of IP (see Fig. 3)

Speed - direction (Component 1 – Component 2): if the speed of acceptance of innovations is greater, the person's social-communication direction of development emerges, and the person's direction on interdependence in interpersonal cooperation and joint development are greater at the same time. If the speed of acceptance of innovations decreases, personalized (internal) direction of development of the person increases.

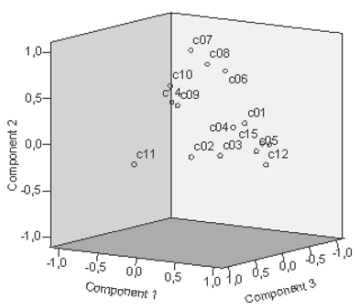


Fig. 2. Component Plot in Rotated Space after the 4th stage

TABLE II
ROTATED COMPONENT MATRIX AFTER 4th STAGE

	Component		
	1	2	3
att_pers	.828	.279	.014
att_prof	.795	-.119	.237
psi	.783	.289	.257
pers	.711	.311	.169
attieks	.516	.459	-.101
prof	.512	.431	.311
pra	.108	.842	.261
iem	.141	.792	.188
zin	.302	.693	.084
arf	.475	.489	.360
arfk	.042	.066	.799
mer	.396	-.030	.647
arft	.061	.296	.608
anx	.125	.340	.456
kom	.407	.367	.417

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Direction - speed (Component 2 - Component 1): if the direction of personal development is more personalized (internal or personal-oriented), speed of acceptance of innovations decreases. If the direction of personal development comes nearer to external social-communication interdependent cooperation, speed of acceptance of innovations increases.

L. Components in Pair №2: Speed - Acceleration (see Fig. 4)

Speed – acceleration (motives) (Component 1 - Component 3): if the speed of acceptance of innovations decreases, the motivation for activities is more internal. If the speed increases, the motivation becomes more external. And on the contrary, external motivation and external locus of control mean higher speed of acceptance of innovations. Internal motivation and internal locus of control mean lower speed of acceptance of innovations.

It means that the increase of a speed of acceptance of innovations is possible only by influencing the person, but the speed of change of innovativeness is lower if internal motivation is involved in a process.

Acceleration - speed (Component 3 - Component 1): if motives are more internal – a speed of acceptance of innovations is low, if motives are external - speed is higher.

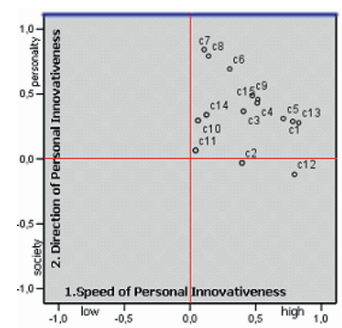


Fig. 3. Components in Pair №1:
Speed of Innovativeness of a Personality (IP) - a Direction of IP.

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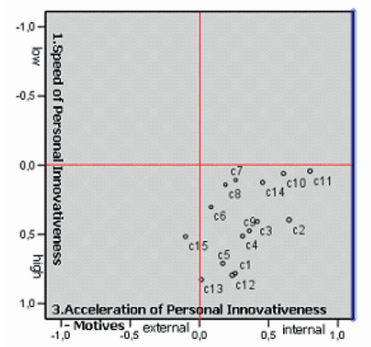


Fig. 4. Components in Pair №2:
Speed - Acceleration (motives)

M. Components in Pair №3: Direction – Acceleration (see Fig. 5)

Acceleration - direction (Component 3 - Component 2): if a motivation is internal, the social direction of innovative development of the person is operated in this process. Motives are directed on expansion of interdependent interpersonal developing cooperation and socialization of a person. If the motivation is more external, the personal-guided direction of development emerges.

It means that in a compulsory process of acceptance of innovations a person is compelled to direct own efforts in order to receive additional knowledge and skills. It eventually will involve process of conscious training and self-training. The attitude to the given process also is important: negative or neutral attitude influences greatly the process of compulsory acceptance of innovations in the case of external locus of control.

Direction - acceleration (Component 2 - Component 3): if a direction of personal innovativeness is more personal, the internal motives operate in the process. If a direction is more socialized, operate external motives. It means that if the process of innovations is imposed by the speed of development of a society it induces involvement of internal motivation - depending on conditions and attitudes of a person.

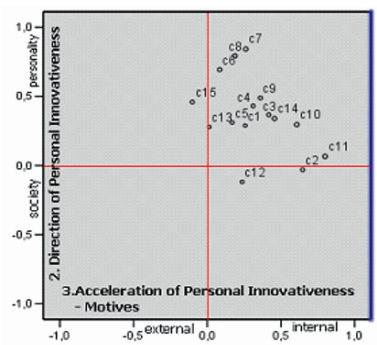


Fig. 5. Components in Pair №3:
Direction - Acceleration (motives):

N. Conclusions after the 4th stage

1. Three components of dynamic interaction can be considered by analogy with physical concepts – speed, direction and acceleration.

2. Dynamic interaction can be presented as a process of fluctuations: changes of speed of development of the academic intelligence of a person (knowledge, skills, abilities); directions of development of emotional intelligence and qualities of a person (psychological personal qualities, purposefulness, skill to communicate, anxiety); changes of a level of innovativeness of a persons: process of changing a level of innovativeness under the influence of conditions of necessity to accept any innovations in professional or educational activity.

V. Models for Describing of Structure and Interactions of Concepts

In order to describe the concept of innovativeness schematically three models of interaction of concepts have been created:

1. The model of structure of leading innovativeness parameters PIM© is created (see Fig. 6).
2. The model of structure "The Leary's Interpersonal Model and Innovativeness" is created (see Fig.7).
3. The model of interaction polarization metaprograms of a personality and innovational anxiety is created MPM© (see Appendix).

VI. Conclusions and Discussion

The usage of the concept describing the level of innovativeness and practical measurement for level of innovativeness of a person are significant for planning and developing training computer systems in all branches; for system engineering management in business and manufacture, control systems for high and basic education, control systems and training of the personnel; for development of all systems of strategic and tactical planning, management, use and development of human resources and the human capital.

The submitted theoretical models and developed scale of measurement of innovativeness of the person demand the further studying carrying out an additional research for verification of the concept. The questionnaire of a structure of metaprograms and level of innovativeness of a personality is developed.

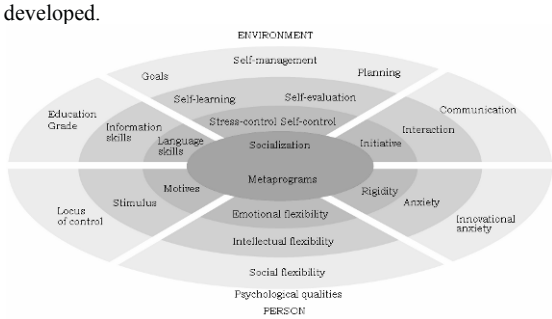


Fig. 6 The Model of Structure of Innovativeness of Personality PIM© 2007

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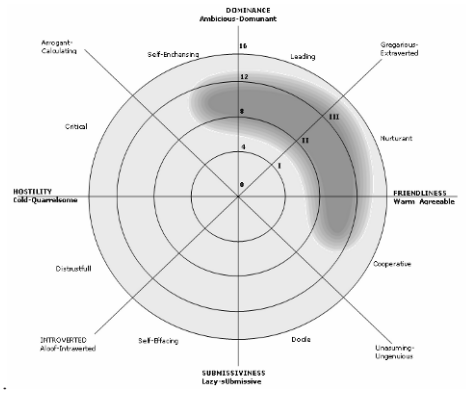


Fig. 7 The Leary's Interpersonal Model and Innovativeness of Personality

As there are no adequate methods for researching the given phenomenon, the development of new tools of research of a structure of metaprograms, metaprograms polarization and innovativeness phenomenon is necessary.

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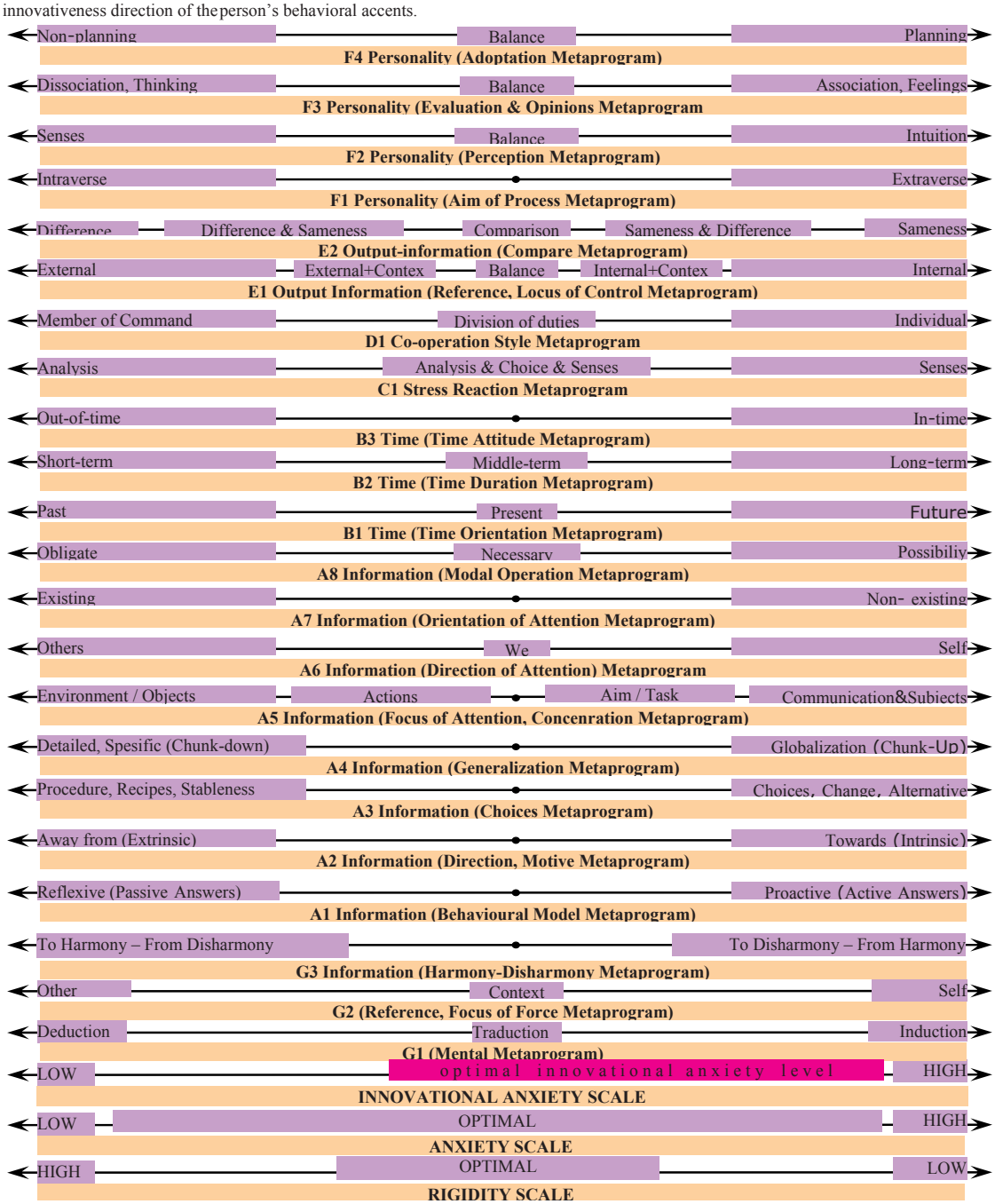
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mmeybodi@aut.ac.ir

Appendix

THE MODEL OF INTERACTION POLARIZATION METAPROGRAMS AND INNOVATIONAL ANXIETY MPM© 2007

As Innovativeness assumes the level of willingness and application of definite models of person' behavior, it is possible to assume the interrelation of The Model of Metaprograms and the Level of Innovativeness in a context of the information perceptional, filtration and processing process, as well as the context of decision-making and formation or change of the certain model of behavior of the person at which Innovativeness Level extent can be presented. During the process of the analysis of various Metaprograms opportunities of classification and association of the some Metaprograms in classes – by the reception of the information (Information), by the ways of processing of the information, on a conclusion of the information and decision-making (Output-information), by the personal characteristics (Personality), by the communications and stress reaction (Stress-reaction) have been determined. Besides, it is possible to distribute some metaprograms the scale with two poles, polarizing some metaprograms in left, central, or the right part of the each metaprogram scale. The result of classification and distribution is submitted on Model. Consequently, in parallel scales of known *Metaprograms* the scale of *Person's Innovativeness* with three areas - low, optimal and high innovativeness is settled down. Drawing up a person's profile on the specified metaprograms, in case more metaprograms at diagnostics is fixed in the right part of the scales or in case the metaprograms are more expressed in the right part, the Innovational Anxiety level is more optimal. Probably combinations of some metaprograms display innovativeness direction of the person's behavioral accents.



mmeybodi@aut.ac.ir

The Role of System Dynamics in Learning Environments

Aasia Riasat[1], Syed S. Rizvi[2], Farheen Zehara[3], and Faraz Arain[4]
Department of Computer Science, Institute of Business Management[1], Karachi, Pakistan
Department of Management and Technology, University of Maryland[3], College park, MD
Computer Science and Engineering Department, University of Bridgeport[2, 4], Bridgeport, CT
aasia.riasat@cbm.edu.pk[1] , fzehara@umuc.edu[3], {srizvi[2], farain[4]}@bridgeport.edu

***Abstract*-Due to increasing demand for simulation and modeling, efforts are needed to build up more powerful simulation and modeling methodologies that can help to facilitate *learning* complex dynamic systems. By learning we mean the acquisition of knowledge, skills and experience for better and faster learning of the various types of complex dynamic systems. System dynamics is one of the successful well formulated methodologies that provides a perfect framework for building highly interactive learning environments where learners involve in reasoning about the relationships between the structure and the dynamics of a complex system. In this paper, we address two recent well known approaches (*Black-Box and Glass-Box*) that enhance learning capabilities in a typical complex dynamic system and demonstrate the overall learning effectiveness by using their own methodologies. Furthermore, we present a critical comparison of traditional black-box approach and the innovative glass-box approach. In addition, we also present two experiments that are associated with the black-box approach. These experiments will be very helpful for understanding the inadequacy of a black-box approach when compare it to the glass-box approach.**

I. Introduction

System dynamics is a field of study founded by Jay Forrester in 1960s at the Massachusetts institute of Technology (MIT). The field has a long history, and has been successfully applied in a variety of economic and social settings, including market simulation. Forrester [3] observed that people usually identify one or two influences and assumed that the final outcome of the problem solely depends on them. Consequently, people implement simple polices for solving problems and quite often those polices have the opposite effects that make problem worse. To help improve decision making, better understanding of complex problem domains, and policy formation, Forrester created the system dynamics methodology.

System dynamics provides a way to represent and model human expectations, and these are typically linked to policy making decisions. In its simplest form, system dynamics mainly focuses on the flow of information transmitted and returned (feedback) through the system's components. It is an approach for analyzing complex systems to include all the relevant cause-effect relationships. In addition, system dynamics analyzes the impact of time delays and feedback loops in those systems that exhibit unexpected behavior. System dynamics based systems provide a frame work for understanding the dynamic interrelationship between system elements [4]. This implies that the system dynamics goes beyond the strict decision support metaphor, and should be applied as a toll conductive to support thinking, group discussion, and most importantly modeling of complex dynamic systems and interaction with learning effectiveness. Recently, some researchers [1] [2] presented two different approaches: *black-box* and *glass-box,* respectively.

II. Significance of System Dynamics in Learning Environments

Different kinds of complexities are adequately handled by a static structure analysis [6]. These complexities which are essentially dynamic, involve feedback, delays, and non-linearities, demand a representational scheme which can model (mathematically represent and conceptually present) the underlying structures which are causally linked to complex, dynamic behavior. System dynamics provides this capability and supports conceptually linking explanations about complex behavior to underlying structure. This allows a learner or decision maker or planner to use a system dynamics simulation as a way to test a hypothesis about how a system will behave in particular circumstances. In other words, we can use system dynamics to understand and explain system behavior in terms of underlying system structure. Furthermore, we can also use system dynamics to show how changes in the structure of a system will lead to changes in its behavior [3].

More recently, learning environments starts using system dynamics that not only useful for modeling the complex dynamic systems but also helpful for providing a methodology that ensures consistent success in the effectiveness of system dynamics based learning environments. For example, the black-box approach for such a learning environment can be best illustrated with the popular learning environments called *SimCity*™ which provides a learner with the scenario about a city that could place him in a situation of ruling the city and making decisions about housing, services, taxes, etc. with the goal of general and sustained city growth and prosperity. The underlying model is never directly revealed to the learner however, he may view the behavior of the system and make different decisions based upon his observations. Since the

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 538–541.
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underlying model is never shown to the learner, his/her inferences about it for the observed behavior might be difficult to make and validate.

Some other popular examples of such environments include *People Express*® and *Beefeater*® which are usually regarded as a two-premier management simulator. These two simulators help adults to learn about factors influencing the growth of a particular business [1]. In addition, system dynamics modeling tolls such as *Stella* and *Powersim* and programs like *StarLogo* and *Agensheets* enable users to experiment with complex systems and develop better intuitions about the mechanisms that govern dynamic interactions [7]. These types of interactive tools allow significant learning with both the models and the modeling techniques.

III. State of the Art Research in System Dynamics based Learning Environments

The goal of black-box approach [1] is to develop a methodology that can be used to not only ensure consistent success in the effectiveness of system dynamics based learning environments but also establish reliable measures of effectiveness for it. They claimed that there is no well established methodology available that can be used to determine which design approach most likely leads to the desired outcome for a certain problem domain and its learning effectiveness. Therefore, they have been particularly involved in developing a 'causal loop mapping tool' and shaping the ways through which it could be more efficiently used to construct a better learning environment and to demonstrate the impacts of system dynamics learning on dynamic problem understanding. Causal loop diagrams (also called causal influence diagram) are quite good at providing a representation of an entire system. Such diagram can be used to support an elaboration of a problem scenario, knowledge elicitation, and assessment of understanding [9].

The main use of this tool is to capture the thinking patterns of the initial and the expert learners for a certain problem domain as *concept maps* and then compare them to analyze their differences in thinking and reasoning of initial learners with the experts. The concepts maps of initial learners and experts are constructed by first creating the causal lop diagrams for a targeted problem domain. It has been shown that [1] with a simpler problem domain; experts exhibit similarities in their thinking and reasoning when we compare their concept maps with that of the initial learners. But as the problem domain becomes complex and dynamic, we may find some obvious differences in their initial causal loop diagrams.

However, the main problem associated with the black-box approach is that the learner is entirely unaware with the underlying structure of the system [2]. In other words, black-box approach supports peer to peer communication and collaboration that plays a vital role in network-learning environments, but unfortunately an initial learner does not have any experience with the actual complexities of the problem domain. Consequently, due to the incomplete identification of all concepts, the initial learners are unable to draw good causal loop diagrams which lead to the conclusion that a better learning environment, based on system dynamics, requires a comprehensive understanding of the complex dynamic problem domains. The glass-box approach accomplishes this task by integrating learning theory, system dynamics, and collaborative tele-learning. This approach is also known as Model Facilitated Learning (MFL).

The glass-box approach emphasizes on the designing of a system dynamics based learning environment where the learner has the knowledge of the underlying structure. Understanding complex system behaviors involve the ability to provide causal and structural explanations [2] as well as the ability to anticipate and explain changes in underlying causes and structures. Thus this implies that the underlying structure of the system should be made more and more accessible to learners for the purpose of explanation and manipulation as the learner becomes more experienced with the complexities of the domain. Such an approach is more consistent from the evaluation methodology point of view. The main aim of glass-box approach is to help learners manage complexity in ways that contribute to improved learning and deep understanding of the complex dynamic problem domain. The black-box approach is an evaluation methodology that involves both quantitative and qualitative methods [5] where as the glass-box approach is primarily qualitative in nature.

The glass-box approach consists of the following three stages: problem orientation, inquiry exploration, and policy development. Of particular interest in the glass-box approach to system dynamics based learning environments is the notion of double-loop learning [7]. In the first loop of learning in the complex systems, learner begins to interpret a system dynamics model of a complex domain. This activity is itself challenging. One might characterize such an activity as using an external model to facilitate the creation of internal mental models. The external model is shared and provides a group of learners or decision makers with a common representation which is required for meaningful discussion. Much collaboration can be built into understanding such models, and such collaboration has generally proven useful.

A second step, however, is required to move learners from familiarity with a complex model to a profound understating of that model. Learners play various roles in simulation based learning environments such as they interact with the environment, make changes in various parameters and then observe the outcomes, and in some cases they can even make their own models. This implies that the second step of this approach brings the learner where he has an influential control over the learning environment. In other words, when learners are asked to make changes in the underlying structure, the realization that structure creates behavior is forced upon them. On the other hand, when learners see themselves as part of the underlying structure, they are more likely to search for a wide range of solutions to problem behavior. This is one of the most important features of the glass-box approach that provides a better learning environment for the learners than the black-box approach where the learners do not have such access and in-depth recursive information about the underlying structure of a complex problem domain. Such interaction helps learners to

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keep a tight connection between the structure and behavior of complex system [8].

IV. Experiments Associated with Black-Box Approach

In this section, we briefly present the following two well known experiments of black-box approach: (a) *pilot experiment* and (b) *flight simulator*.

A. Pilot Experiment

The Pilot experiment was conducted using three cases of the following dynamic problems: (1) Spread of an infection; (2) Yeast production; and (3) Deer population. In each domain, initially two experts were asked to produce causal loop diagrams on paper. The suggested test tool includes a dynamic description of a problem and a questionnaire. These questionnaires were distributed randomly among students that had no prior experience with system dynamics and system thinking. On a very first day, they were asked to answer relatively simple problems. After the first day, students attended an introductory lecture where they were learned the concepts of feedback, causal relationship, and causal loop diagramming etc. At the end of the second day, students were asked to fill in the questionnaires again, only they were asked to pick up a different problem than they had on the previous day. The data collected from the questionnaire was used to identify that (a) how subjects understand dynamic problems description, (b) how they understand what they were asked to do, (c) what concepts they perceive as important, and (d) how they relate them each other. The three problems that have been considered as a test tools can be graded according to the level of dynamic complexity that they include. For learning more about this experiment, please see [1].

B. Flight Simulator Experiment

The concept of a flight simulator tool was pioneered in the system dynamics community [10], and that architecture for system dynamics based learning environments has become the predominant architecture. This experiment consists of the following three steps: (a) in order to get new and elementary questions, they use computer based tutors which do not depend on system dynamics, (b) use of mental modeling or concept mapping techniques to build up models of experts thinking and reasoning in complex domains, and (c) use the same techniques in advance stages to determine the overall effectiveness of the simulator.

V. A Critical Assessment to the Results & Evaluation of Experiments

In this section, we describe the results of the experiments we presented in the last section. Furthermore, in this section we present our critical assessment specifically to the results of these experiments and the black-box approach in general.

A. Results of Black-Box Experiments

In the first experiment, the first dynamic problem (Spread of an infection) was comparatively easy to understand. According to the results [1], most of the people correctly identified most of the concepts related to the population. However, not all people were able to identify the effects of density and connectivity on the infection rate. It is possible that some people might have confused by the description of the rate of infection and the rate of contacts. According to the results, in some cases, people did not notice that the total population is not changing and also how the density of a certain fraction of population is defined. None of the subjects indicated such parameters as the probability of infection [1]. Similarly, in the second dynamic problem (yeast production problem), most of the people identified most of the concepts and some of them were even able to identify the relationships and effects. However, they also tended to introduce the concepts which are not included in the suggested solution. Finally, in the third dynamic problem (deer population), most of the people identified only the concepts related to the deer population, but very few did mentioned concept related to the predator population.

In the second experiment, flight simulator takes into account the importance for small group collaborations and it situates the learning in realistic settings. In other words, one can make a conclusion that it is useful in the early stages of learning development to challenge learners to identify what they believe to be the most influential factor, perturb the system with a slight change and then predict the outcome. However, what is not provided in such flight simulator is support to help learners reason from observed system behavior to underlying structural causes or to alter the underlying structure and reason forward to predict outcomes.

In one of the well known studies [12, 13], 75 online discussion forums are selected at random for analysis. The only criterion for selection was based on the number of participants where each forum is typically considered as an observed network. As mention in above approaches, each participant is characterized by the total response capacity the participant has which yields total number of response links. The distribution of the sizes and the total response capacities of the networks are shown in Fig.1. It should be noted in Fig. 1 that each point represents one network.

B. Critical Assessment

Both simulation models that have presented in the last section run in cycles. After each cycle, a group of learners are asked to indicate the current state of the system. The learners have opportunity to possibly change a few key factors and then predict what the state of the system would be at the end of the next cycle. Reference [8] reports that this black-box approach has certain advantages and disadvantages that we present in the next section. In general, almost all black-box based learning environments have the following characteristics: small group collaborations that spread throughout the learning experience, opportunities to formulate policies that help in decision making, and opportunities to analyze results and reflect upon the decision making process.

The simulation models that based on black-box approach often fails to help integrate all of the knowledge, skills, attitudes, and judgment desired in graduates of the learning experience, and they explicitly fails to comply with the

mmeybodi@aut.ac.ir

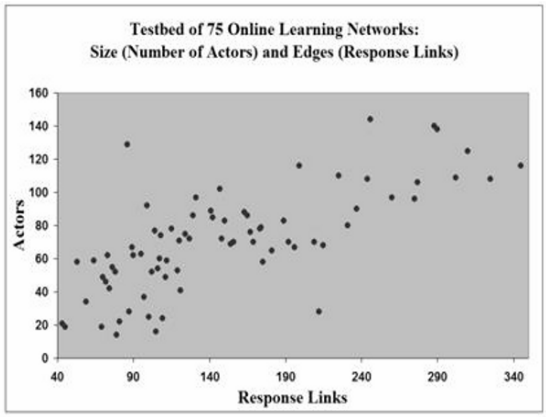


Fig.1 Nodes with trust and reputation

principle suggested by elaboration theory and made specific in the cognitive apprenticeship model. New learners should be provided with more support as compare to more advanced learners. Consistent with this principle is the notion that support should be adequate to lead most learners to the desired level of knowledge, skill, or judgment in a reasonable amount of time. With regard to complex systems, if the underlying model that is causally linked to the behavior of the system is kept hidden, then either learners take long time to infer the cause or most fail to find the cause [11].

VI. Conclusion

We present two approaches that greatly involve in system dynamics based learning environments. We argue that the black-box approach has certain advantages but it is only appropriate as long as we have a simple problem domain. As learners become more proficient in using the simulation, they need to access the underlying simulation model in order to improve their understanding. The bottom line is, if the learners do not have access to the underlying simulation model (a black-box approach), learners are unable to develop deep causal understating of a complex system. Consequently, learners are unable to identify correct concepts related to the complex problem domains and unable to draw perfect causal loop diagrams. This implies a glass-box approach is not only provides an access and insight to underlying simulation model but also offers an adequate standard qualitative measure to evaluate the overall effectiveness of the system dynamics based learning environments.

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mmeybodi@aut.ac.ir

Dynamic Semantics of the Web: Useful Tool for the New Generation Agent-Based Software

Aasia Riasat[1], Syed S. Rizvi[2], Faraz Arain[3], Rizwan M. Qureshi[4]
Department of Computer Science, Institute of Business Management[1], Karachi, Pakistan
Computer Science and Engineering Department, University of Bridgeport[2, 3, 4], Bridgeport, CT
aasia.riasat@cbm.edu.pk[1], {srizvi[2], farain[3],mqureshi}@bridgeport.edu

Abstract— **A complex relationship between the semantic and the dynamic web is derived based on the concepts of ontology engineering. The resultant complex relationship can then be used to construct new generation intelligent agent-based software. Although the World Wide Web (WWW) was originally designed as a distributed information space that supported human navigation through related linked documents, the machine or software agent based assistance has been hindered by the type of markup used within the documents. Our derived relationship can show that how the dynamic semantics of the web enables software agents to derive underlying semantics on the basis of common ontologies and common agreed semantic to generate and process the semantics dynamically. In addition, an ontological relationship between the static and the dynamic semantics of the web is also presented. The Ontological view of this concept highlights the need of dynamic web semantics. Also, we show that how the dynamic semantics will be enabled by and useful to the new generation of the intelligent agent software that will increasingly inhabit the web in the coming years.**

I. Introduction

World Wide Web (WWW) has drastically changed the availability of electronically accessible information. Currently, there are around three billion static documents in the www that are used by more than 200 million users internationally [8]. However, the rapid growth of the www makes it increasingly difficult to find, access, present and maintain information of use to a void variety of users. Currently, pages on the web must use the representation in formal language such as HTML [9] and employ protocols that allow browsers to represent information to the human users. The information contents, however, is mainly presented via natural language. Thus, there is a wide gap between the information available for tools to use in creating and maintaining the web pages and the information kept in human readable form on those pages, a gap that causes serious problems in accessing and processing the available information.

The next phase of the web called the semantics web, stores the information regarding the properties and the relationships between the objects on the web. The semantics that changes relatively slowly as web pages are created, destroyed or modified typically by human action is called the declarative or static semantic. Equal importance should be given to the dynamic semantic that involves the web contents generated on the fly in response to some user request. In static semantics a web page may also include metadata about certain web pages (written in RDF, SHOE or OIL) [5, 6]. Using dynamic semantics we can enable a web page to compute a metadata from human understandable information, which not only stores information about other web pages, but also stores information about the user activity, user interest and the structure of the text. This paper presents the relationship between static and dynamic semantics of the web. In addition, it highlights the need of dynamic web semantics and discusses how the dynamic semantics will be enabled by and useful to the new generation of the intelligent agent software that will increasingly inhabit the web in the coming years.

Since the vision of the semantic web is now closed to be a reality, with the goal of giving semantics to the static contents of the web, this paper emphasizes the need to make the web a dynamic semantic web by programming the procedures in the web material as a first class objects. In this context, this paper reviews the new language of formal semantics "Glue" which is an XML based web programming language that completely integrates static and dynamic semantics of the web, recently proposed by the researchers at MIT [7].

The rest of the paper is organized as follows. In section 2, we present a comprehensive comparative analysis of static and dynamic semantics of the web. Particularly, we demonstrate that how the deployment of dynamic semantics can affect the upcoming implementation of the semantic web. In section 3 of this paper, we review the new language GLUE which is an xml based extension of html that integrates static and dynamic semantics of the web. In section 4 we will conclude the paper.

II. Complexities of Static and Dynamic Semantics of The Web

As Discussed in the first section adding static semantics to web contents empowers the web to let software agents and machines to extract and reason the information that is over the web, however as knowledge becomes complex and huge its static semantics description will sooner become less useful and complete. This fact implies that some other mechanism

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 542–547.
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mmeybodi@aut.ac.ir

should be adopted by the semantic web researchers to get the full advantage of the future semantic web and to tackle this potential problem the future semantic web will face. We believe that, the dynamic semantics has the potential to over come this prevailing problem of static semantics of the web. The successful implementation of dynamic semantics of the web can not be achieved unless the researchers have a sound understanding of various semantics: their nature, sources and their applications to varying web semantics usage scenarios.

In this section we follow the same organization to give a better understanding of our audience about the dynamic semantics of the web. We first describe various semantics that are involved in the semantic web vision, identify relationships between static and dynamic semantic of the web and highlight their relative importance to the big picture of semantic web vision. Our main emphasis here remain on the extreme importance of the dynamic semantics and the advantage that it offers to greater enhance the semantic web potential, and how well it suits with the current requirements of the dynamically changing requirements of semantics web.

A. The Future Semantic Web - A big picture

A set of widely established standards guarantees interoperability at various levels and hence the concept of semantic web is soon to become a reality. Current web has been designed for human processing where as Semantic Web vision aims at developing a global medium of information exchange while extending the web with structured contents and machine-understandable information.

The future semantics web will enable intelligent services such as intelligent information services, personalized Web-sites, and semantically empowered search engines, and knowledge base information retrieval along with improved functionality and interoperability. To make machine knows what to do with information on the web is to enable machine to read and process a machine process-able specification of the semantics of the information. This is a very challenging approach and mostly beyond the current state of the web. A much simpler approach is to let the Web application developers to hardwire the knowledge into the software so that when the machine/agent runs the software, it does the correct thing with the information. In this second situation, machines already use information on the Web.

B. What is Semantic? Where it originates?

Semantics appears in fact at various layers of applications of the semantic web. For a simple personal Web site with the purpose of presenting some information, developers could use HTML or XML. This markup language has its own semantics. When we develop a model of knowledge or a commonly agreed domain specific knowledge (such as ontologies), that can be represented by means of a computer language (DAML+OIL, SHOE) with certain semantics. To annotate a Web document by a reference to a model of knowledge, we will use some specific language and its semantics

Theses Semantic Web contexts include: achieving successful communication among agents on the Web, the meaning of the content of various information sources that agents require in order to perform their tasks as shown in Fig. 1. Our focus here is to describe complete detail about what different kind of semantics are involved in the semantic web, what scenarios include semantics, where these semantics actually exist or generated are and how they are used. Our emphasis is on the kind of semantic involved ranging from the various semantics that exist in the today's WWW to a complex semantic infrastructure that will exist in the Semantic Web of the future.

C. Implicit Semantics -Common Consensus

When meaning is conveyed by means of a shared understanding derived from human consensus or a commonly used terminology of some entity, it is categorized as implicit semantics. The common terminology includes price, order, invoice, date of shipping etc. Since on the basis of this implicit shared consensus about what these terms mean, then application developers can hardcode this implicit semantics into web application programs using wrappers. This is the way today's shopping agents and shopbot applications are implemented that search web sites for the best deals based on what is directed or coded within the application. The downside of the implicit semantics is that they are filled with complexity or irregularity. It is not necessary that the people always agree on the meaning and the use of the same term. The amount of efforts required to remove this irregularity is too high as it demands to have some publicly accepted terminology to share it at global scale with consistency.

D. Informal Semantics - Static Web Semantic

Semantics can be explicitly expressed in an informal manner, e.g., describing resources over the web using the RDF. This semantics is provided basically for humans, machines still can not infer any useful knowledge from this informally expressed semantics. Many examples of informal semantics exist such as: read-me text specification documents. HTML tags specifications, UML for expressing a model, documents or resources specifications using RDF or RDF Schema, Dublin Core definitions of the terms. In order to make use of this informal semantics, the application software hardwires the semantics in order to let software work in specified manner. The example of informal semantics include: compilers written over language descriptions, RDF and UML descriptions to develop modeling tools like Rational Rose. This ambiguity may arise again by the use of this semantics with inconsistency or incompatibility in its two different implementations with different features and characteristics. This will cause interoperability problems among separate implementation and hence an informal static semantics sometimes becomes a bottleneck to implement the semantic web motive to improve and enhanced interpretability. This problem highlights the need and motivates towards the

mmeybodi@aut.ac.ir

development of formal (Dynamic Semantics) semantics of the web.

E. Formal Semantics -Human Processing

Semantics can be expressed explicitly in a formal language, but intended to serve the purpose of human processing only. Examples of formal semantics include formal specifications of defining ontological categories. Again these specifications are to enhance the ability of humans processing and to reduce the ambiguity in defining the meaning of these ideas. This modeling of the logic enhances communication between web agents. The cross layer designed is presented in Fig. 2. The Ontologies on different information domains have been created in an attempt to help better communication of terminologies for same domains can be established. Again this involves inherited problems if these ontologies would be used for automated inference.

F. Formal Semantics-Machine Processing: The Basis of Dynamic Semantics

The heart of Semantics Web idea is to make web contents machine process-able that is machine can understand the web content it encounters. This ideology requires that the semantics can be hard-coded within the Web applications along with the existence of a commonly agreed, overall consistent, and well established semantics. The problem here arises with the size of knowledge domain to grow as related domain information grows and consequently the knowledge description (formal-static semantics) will become more difficult to manage. In order to handle this problem effectively another efficient approach is to formally represent the semantics and allow the machine to process it to dynamically discover what the content means and how to use it. This semantics is categorized as formal dynamic semantics for machine processing. Still this is a future possibility to achieve this goal in its full entirety of enabling machine to generate and process the dynamic semantic completely randomly. Some of the possible questions that we face in this idea to implement include: How to enable a software agent to learn something about the meaning of a term that it has never before encountered? There comes the procedural or dynamic semantics perspective.

From the procedural perspective: the question is how agent can learn the meaning of a new term from a formal,

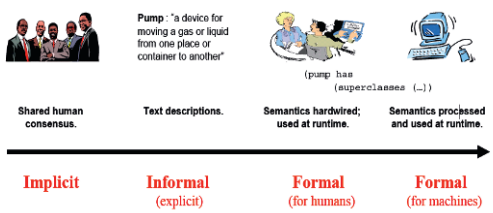


Fig.1: Heterogeneous Semantics of Semantic Web

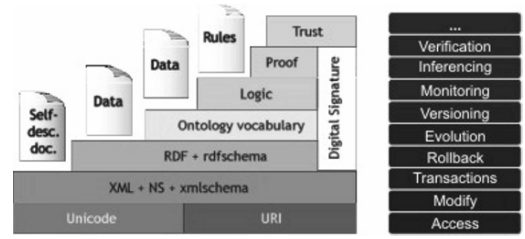


Fig. 2. Ontological view of the complex dynamic semantic of the web

declarative semantics. For dynamic semantics generation we would like to do this without making any assumptions at all. In this case, all symbols might as well be in a never-before encountered terms for the web agents. We have no knowledge of the meaning of the symbols, the rules of syntax for the language. However, we may have some information on the semantics of the language in the form of an ontology is available. This paradigm is most challenging, and difficult for machines to work for.

III. Dynamic Semantics – Possible Challenges

There can be some prevailing problems when trying to implement dynamic semantics generation. One problem can arise due to the different ontology languages based on different description logic. Other differences can be based on degree of expressiveness, details of formally defined semantics, existence of inference support, etc. If we keep these different ontology languages in mind this will be a difficult task to perform dynamic translation in between. This task could be made easy if we assume that the terms that the agent will encounter are from one ontology language whose syntax and semantics (such as RDF schema or DAML+OIL) are already known to the web agent.

Again if we assume that a commonly agreed ontology language is available, it can have incompatible assumptions in the conceptualization. From a logic perspective, the two representations may use the same language. As a result another assumption that needs to be made is: that the underlying conceptualizations of ontologies are compatible. If we assume the above two conditions of a shared language and compatible conceptualizations, it is still possible, that two different language's terms may have the same meaning and the same term may have two different meanings. The same ideas may be described using different levels of details, different set of primitives, modeled in different structures.

G. The Static Semantic Web - Current Picture

In today's Semantic Web concept: XML, RDF, SHOE+OIL languages have been introduced as formal languages for expressing concepts and relations that exist in the knowledge description of the contents (documents or resources) over the web and to provide machine understandable meaning to enable machine processing the web contents in an efficient way. In static semantics the web is typically viewed as a repository of web pages including meta-data (using XML,

mmeybodi@aut.ac.ir

RDF, SHOE, OIL, etc.), which consists of the information about all the web page contents, their resources, objects and their links. The web in this model is database of information that changes rare through database upgrades.

However, all this is limited to static semantics. These knowledge descriptions are authored by its author in exactly the same way that HTML pages are presently authored by a Web designer [1]. This static semantic is represented declaratively in the form of passive data that can be retrieved and changes relatively slowly when the web page in created, modified or destroyed. Since these events are rare to happen this authoring of the knowledge description become a rare activity. Structured static semantics are a huge advance for the web since they will enable software agents to find and reason about information over the web, but as mentioned the problem with the structure static semantic is that : the larger and more complex the knowledge, the less complete and useful its static representations become. In addition the modification of the description and keep it up to date will become a tedious task to perform.

For static semantics, there is no alternative other than to hardwire it into the web application software to let software agents perform the task as dictated by the code. In the case of formal partially dynamic semantics: it always serves the important role in reducing ambiguity and the complexity in specifying Web application behavior, compared to static informal semantics. There is always a possibility of using automated inference to process the semantics at runtime. This would allow for much more efficient, consistent and autonomous Web applications, in which agents automatically learn something about the meaning of terms at runtime by generating dynamics semantics.

H. Dynamic Semantic Web – A Potential Opportunity

The Dynamic semantics is represented procedurally & computed by applications running on the client or server side, based on immediate user input, context, real time and user-initiated actions. It changes relatively rapidly. A single user click can cause the semantics to be generated or to change, or it can be changed by the actions of programs continuously in real-time [2]. As the idea of the semantic web flourish, there are many ways in which static semantics are being augmented and replaced randomly by dynamic semantics. The Web application that render the dynamic contents such as : an Active Server Page extract results from the database and constructs a page on the fly or the search engine results pages, and customized ads based on cookies are examples of dynamically created Web pages. The important relation ship between static and dynamic contents of the web page make the originating source of the contents entirely transparent to the browser. The HTTP stream that is delivered by some random procedure call is identical to that which would have come from a statically stored page [4]. This transparency between static and dynamic data is an extremely important property of the web that can be exploited efficiently to replace or extend the dynamic contents such as replacing some static data over the web page stream with a new, dynamically generated or calculated data at run time.

I. The Origins and Usage of Dynamic Semantics

The potential sources of dynamic semantics generation are the intelligent web software agents. These are intelligent web applications that provide useful assistants to the user. They keep track of the user interests, learn through interacting with user, explore the Web proactively depending on the user interactions and provide personalized services and information. The examples are intelligent shopping agent programs that provide the pricing information available over different web sites about a product to the user.

The real power of the Semantic Web will be realized when people will be able to create many web agent software applications that collect web content from diverse sources, process the information by generating the dynamic semantics i.e., the meaning of how to infer this information and exchange the results with other software agent application. The effectiveness and the utility of such software agents will increase exponentially as more machine-process-able Web content and automated information extraction and retrieval services including other software agents of the same domain will be added to this picture as shown in Fig. 3. The Semantic Web promotes the idea of web agents working together and transferring requested information among themselves when the data and semantics combined become available to the web agents.

Web agents are unique since compute concepts and relations dynamically from the data stored and retrieved on the Web, form user's interaction, or with the procedure tags attached with the data. Example are the shopping agents: they extract the information by exploring different web sites, querying their search forms, extracting relative information and showing the results in lowest to highest price order. They provide the valuable information by saving the user time and convenient of giving them the knowledge of smart price choices on a single click. In this process of self learning the

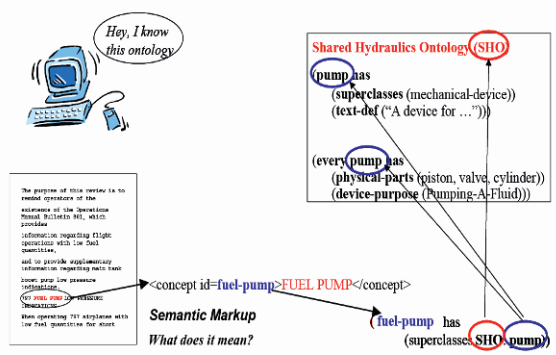


Fig.3: Web agents and the generation of Dynamic Semantics.

mmeybodi@aut.ac.ir

web software agents generate dynamic semantics and utilized the same to continue their search goals or to communicate with other similar shopping agents online.

IV. Web Agent software Methodology

Current web agents work in the complete absence of any formal Semantics over the web. This is because in the current web no web sites provide any clues about what kind of contents are being placed over the web site. How web agents make use of current web contents in the apparent absence of semantics. This is because the way to interact with a web site, what to look for, how to query and how to extract the information is completely hardwired within the application code of the agent. There is no common agreement among different Web sites for how they will use the terminology, even though there is much similarity of the relevant concepts. The machine or the web agent knows what to do with the content. Because the developers hardwire the semantics of the content that will be encountered by the web agents and web agent response and create appropriate procedures that execute. So the web agents can work without any formal representation of semantics and even without any explicit representation of semantics at all. But of course their performance will be extremely restricted to the limited knowledge they have and the availability of the data structure and the semantics over the web that is hardwire in them.

A. Web Agents and the power of Dynamic Semantics

Once data and semantics are made available this will allow web agents to do problem-solving and highly relevant knowledge base retrieval over the web by going beyond the traditional keyword based information retrieval methods. Web agents keep track of the users' browsers history and use it as a persistent context. Let us consider a simple example of how the intelligent web software agents can effectively make use of dynamic semantics i.e., machine processing of formal semantics with current technology. We are assuming that the web agent is using a commonly agreed terminology based publicly declared ontology language with complete conceptual compatibility.

Assume that a web software agent is searching for information about mechanical devices over the web. It is using a public ontology (SHO) language. Web agent encounters a term "Fuel Pump," which the agent has never encountered. Semantic description assists the web agent to refer to the concept fuel-pump, which is a kind of "pump," which is defined in SHO as a kind of mechanical device. The agent infers that the document is relevant. On the basis of this inference web agent knows that it is some kind of pump. This information allow the web agent to return the document containing this term as being relevant to the search of mechanical devices, even though web agents never before had any clues about the term fuel-pump. This scenario illustrates the potential of inferring the meaning of knowledge that is imparted to the web contents, the importance of shared ontologies and the effectiveness of dynamic semantics generation and its usage that enables the web agents to work in an automated manner to learn how to generate semantics and how to make use of it. The power of formal ontologies and automated inference can be joined together to derive a knowledge base for a wide variety of purposes. It allows agents to use theorem proving and consistency checking techniques to determine whether or not they have common semantics agreement and to infer the meaning of complex expressions built up using language primitives [3].

V. An Overview Of Formal Language Of Semantics - Glue

One possible question that arises is: how future Semantic Web should be able to integrate not only text, links, and semantic descriptions, but also dynamic and procedural semantics in it? The existing web standards allow adding well defined semantics over the Web. However, procedural or dynamic semantics has not been covered by any of the existing proposals. Most today's web applications are a combination of several programming languages, such as java-script, Java Servlets, Perl, VB-script, PHP and ASP etc. The disadvantages of such multi-language environments should be obvious.

Along with the above problems outlines, the worst problem that exists with the given scenario is: With the availability of wide variety of prevailing languages, it prevents representing procedural or dynamic semantics in any sort of specified or standard way. The web definitely needs the integrity of overall existing Web functionality, along with the ability to tackle the challenges the future web applications need to face. What is needed here is a language that will unify all the static and dynamic aspects of the web application's functionality with it and eliminate the efforts that are needed to learn variety of languages. In addition to cut down the learning efforts we need to extend HMTL to encode procedural/dynamic semantics in Web pages and employ XML as data structuring language as it is well known and standardized to enable better interoperability over the web.

The web development language that is recently being proposed by some of the MIT researcher is called "Glue". Glue is an XML based web programming language, which is an extension to html and it completely integrates static and dynamic semantics of the web in one unified manner. This language provides the three primary featured functionalities of web development into one unified language.

Developer can simply insert tags into the page. Plain text, markup, data, and code can be freely combined together on a page with no barriers between different functionalities and no "data format mismatches" and the most functionality as desired.

B. Glue – Some Examples Analysis

Here is an example of generating a catalogue for a store. To setup inventory "database", data is entered here directly as a vector of vectors like so:

<set root.inventory

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```
<vector
        <vector "Flannel Top Sheet" "17.95"/>
        <vector "Satin Pillow Case" "11.45"/>
 />
/>
<set page <p>For our every day unbeatable price we have
</p> />
root.inventory.<for_each>
page.content.<push field_value.0/>
page.content.<push " for the low price of "/>
page.content.<push field_value.1/>
page.content.<push <br/>/>
</for_each>
```

At the end of running this program the "page" variable contains our page object. We can get the string of HTML like so : page.<to_html/>

To Add some dynamic variability based on the day of the month:

```
<set root.is_sale_day <date/>.day_of_month.<same 1/> />
```

Now is_sale_day is true if its the first day of the month and false otherwise.

```
<set page <if root.is_sale_day <p>On Sale today we
have</p>
    true <p>For our everyday unbeatable price we have</p>
    </if>
/>
```

The heading to our page is now customized; we can do the same for the body:

```
root.items.
 <for_each>
   <set price
    field_value.1.<times <if> root.is_sale_day true 1
      .75</if>/>
    />
    page.content.<push field_value.0/>" for the low price of
"/> price <br/>/>
  <for_each>
```

Above the price will be multiplied dynamically by .75 if we're on the first of the month.

C. *Glue Comparison with Java Language Analysis*

Some Glue's features fix the inconsistencies and complexities inherent in Java language as outlined below. Glue data types are full-fledged objects. While java contains simple data types and objects, which adds in the complexity. Glue has true multiple inheritances. Whereas Java uses interfaces to allow multiple inheritance. This approach increases undue complexity. Glue supports both a prefix syntax and an infix syntax –automatically and hence does not need require precedence rules or parentheses.

Unlike Java, Glue's "evaluation kinds" permit the easy construction of high-level code manipulation methods which reduces the complexity of packaging up and calling advanced functionality. This enables developers to write their own control structures and other methods that can "delay evaluation" until a programmer-chosen time. In Glue, there is no need to create a class with one instance object. In Glue object can be treated just like an instance object and this is because of Glue's prototype object system. One can call its methods directly using the "class" as "this". There is no need to have a distinction between static variables and instance variables, nor static and instance methods.

VI. Conclusion

We have presented some future possibilities and potentials of the semantic web form the Dynamic Semantic Web perspective. We have shown that the heart of the semantics web is the availability of machine-process able Web content. In this paper, we discussed the concept of semantic web and some of the challenges that are big obstacle in making it a reality. We described various semantics involved and emphasized on the point that the success of the Semantic Web correlates with the ability of Web applications to correctly determine the intended semantics of web contents. In this paper we shed the light on the use and advantages of formal semantics for machine processing which enable us to dynamically infer something about the meaning of the contents over the web in real time. We have shown that instead of just hardwiring the informal semantics over the web, the greater advantages can be gained by hardwiring the semantics of the common ontology specification languages that enable web agent to perform dynamic semantic generation and inference.

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mmeybodi@aut.ac.ir

Reducing Assessment Complexity of Stem-Responses with Belnap's Logic

S. Encheva
Stord/Haugesund University College
Bjørnsonsg. 45, 5528 Haugesund
Norway

S. Tumin
IT Dept., University of Bergen
PO Box 7800, 5020 Bergen
Norway

Abstract- Most automated tests assessing students understanding of a concept contain one question requiring application of that concept. To attain a higher level of certainty in the evaluation process we propose a test with three different questions requiring application of one concept. Such a test is intended to facilitate the self-assessment process and can be suggested to students after a concept has been introduced.

Lattice theory and higher-order logic are further applied for presenting a structure that can serve as a building block of an intelligent tutoring system.

I. Introduction

A lot of research has been done on evaluating students' knowledge during the last few decades. Considerable part of that research aims at developing automated tests providing immediate feedback. A common drawback of such tests is that they employ Boolean logic in the process of decision making. Thus if the response does not appear to be necessarily true, the system selects false. While Boolean logic appears to be sufficient for most everyday reasoning, it is certainly unable to provide meaningful conclusions in presence of inconsistent and/or incomplete input [5], [8]. This problem can be resolved by applying many-valued logic.

Another interesting issue regarding assessment of knowledge is related to the number of questions one should ask while establishing students' level of understanding of a particular concept. We propose short tests that can be incorporated in an intelligent tutoring system, where each test contains three questions requiring a particular concept application. Such a test can be suggested to students after a concept has been introduced and at the end of a semester.

Introducing more than one question helps to attain a higher level of certainty in the process of decision making. At the same time the number of possible answer combinations increases rapidly. In practice it appears to be quite difficult and time consuming to find a proper response to each answer combination. In order to overcome this obstacle we propose grouping of all possible answer combinations into meaningful sets first. Drawing conclusions and providing recommendations, comes afterwards.

The rest of the paper is organized as follows. Related work, basic terms and concepts are presented in Section II. The management model is described in Section III. The paper ends with a description of the system in Section IV and a conclusion in Section V.

II. BACKGROUND

Let P be a non-empty ordered set. If $sup\{x,y\}$ and $inf\{x,y\}$ exist for all $x,y \in P$, then P is called a *lattice*, [2]. In a lattice illustrating partial ordering of knowledge values, the logical conjunction is identified with the meet operation and the logical disjunction with the join operation.

Nested line diagrams are used for visualizing large concept lattices, emphasizing sub-structures and regularities, and combining conceptual scales, [13]. A nested line diagram consists of an outer line diagram, which contains in each node inner diagrams.

The semantic characterization of a four-valued logic for expressing practical deductive processes is presented in [1]. The Belnap's logic has four truth values

- *true* (T),
- *false* (F),
- *both* (B),
- *none* (N).

The meaning of these values can be described as follows: an atomic sentence is stated to be true only (T), an atomic sentence is stated to be false only (F), an atomic sentence is stated to be both true and false, for instance, by different sources, or in different points of time (B), and an atomic sentences status is unknown. That is, neither true, nor false (N).

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 548–553.
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mmeybodi@aut.ac.ir

A logic lattice for the four truth values is shown on Fig. 1.

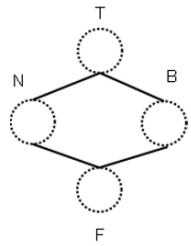


Fig.1. Logic lattice for the truth values in Belnap's logic.

A truth table for the ontological operation $\wedge$ is presented in Fig. 2.

$\wedge$	T	B	N	F
T	T	B	N	F
B	B	B	F	F
N	N	F	N	F
F	F	F	F	F

Fig. 2. Truth table for the ontological operation $\wedge$ in Belnap's logic

The five-valued logic introduced in [3] is based on the following truth values:

- unknown or undefined (*uu*),
- possibly known but consistent (*kk*),
- false (*ff*),
- true (*tt*),
- inconsistent (*ww*).

A logic lattice for the four truth values is shown on Fig. 2.

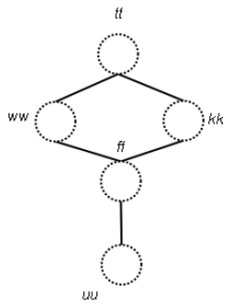


Fig. 3. Lattice of the five-valued logic

A truth table for the ontological operation $\vee$ is presented on Fig. 4.

$\vee$	*uu*	*kk*	*ff*	*tt*	*ww*
uu	*uu*	*kk*	*uu*	*tt*	*ww*
kk	*kk*	*kk*	*kk*	*tt*	*kk*
ff	*uu*	*kk*	*ff*	*tt*	*ww*
tt	*tt*	*tt*	*tt*	*tt*	*tt*
ww	*ww*	*kk*	*ww*	*tt*	*ww*

Fig. 4. Truth table for the ontological operation $\vee$ in five-valued logic

A level-based instruction model is proposed in [10]. A model for student knowledge diagnosis through adaptive testing is presented in [6]. An approach for integrating intelligent agents, user models, and automatic content categorization in a virtual environment is presented in [11].

The Questionmark system [9] applies multiple response questions where a set of options is presented following a question stem. The final outcome is in a binary form, i.e. correct or incorrect because the system is based on Boolean logic [4], [12].

III. ESTABLISHING LEVEL OF UNDERSTANDING

For establishing the current level of understanding of a concept we propose a multiple choice test with three questions. A student can take the test several times after the concept has been introduced and once at the end of the semester.

The 'summarized' result of the student's responses after the concept has been introduced is obtained applying $\vee$ operation for truth values in a five valued logic, [3]. Since the $\vee$ operation is both associative and commutative we can present both to the student and to the lecturer the result of each test and the 'summarized' result of all tests taken by the student. All possible responses are grouped in four sets as illustrated on Fig. 8. Each of the four sets contains five of the twenty possible answer combinations. Any five answer combinations within one set are arranged in a lattice like the one shown on Fig. 3. Thus all the twenty possible answer combinations are reduced to four cases, that correspond to the truth values in Belnap's logic

The final outcome is a result of the $\wedge$ operation between the 'summarized' result of all tests taken after the concept has been introduced and the test at the end of the semester. The corresponding truth values assigned to those two results are from the Belnap's logic, [1].

Every answer in a test can be correct *c*, incorrect *i* or partially correct *p*. The case where no answer is provided is denoted by *n*.

Thus we obtain the following twenty answer combinations:

mmeybodi@aut.ac.ir

ccc - three correct answers
ccp - two correct answers and one partially correct answer
ccn - two correct answers and one unanswered question
cci - two correct answers and one incorrect answer
cpp - one correct answer and two partially correct answers
cnn - one correct answer and two unanswered questions
cii - one correct answer and two incorrect answers
cpn - one correct answer, one partially correct answer, one unanswered question
cpi - one correct answer, one partially correct answer, and one incorrect answer
cni - one correct answer, one unanswered question, and one incorrect answer
ppp - three partially answers
ppn - two partially answers and one unanswered question
ppi - two partially answers and one incorrect answer
pnn - one partially answer and two unanswered questions
pii - one partially answer and two incorrect answers
pni - one partially answer, one unanswered question and one incorrect answer
nnn - three unanswered questions
nni - two unanswered questions and one incorrect answer
nii - one unanswered question and two incorrect answers
iii - three incorrect answers

IV. INNER and OUTER LATTICES

Inner lattices - all answer combinations are grouped in the four lattices with respect to the five truth values, [3].

Any two nodes, in Fig. 5, Fig. 6, Fig. 7, and Fig. 8 connected by an edge differ in one answer only. Going upwards from one level to another in the lattices on Fig. 5, Fig. 6, Fig. 7, and Fig. 8 increases the level of knowledge.

Outer lattice – the lattice with the four truth values of Belnap's logic from Fig. 1.

Nested lattice - the previously described twenty answer combinations are arranged in a nested lattice, Fig. 9. This lattice visualizes the learning progress of each student.

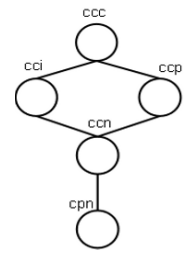


Fig. 5. Answer combinations related to the truth value *tt*

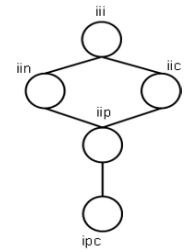


Fig.6. Answer combinations related to the truth value *ww*

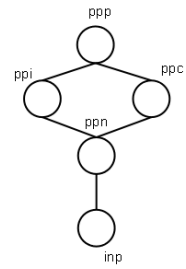


Fig. 7. Answer combinations related to the truth value *pp*

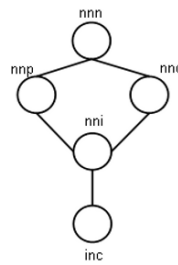


Fig. 8. Answer combinations related to the truth value *nn*

The 'summarized' result of tests, taken after a concept is introduced, can move inside one of the four outer circles. This implies changes of the understanding status within one of the five truth values. If it moves from one of the outer circles to

mmeybodi@aut.ac.ir

another than it implies changes of the understanding status between two of the four truth values.

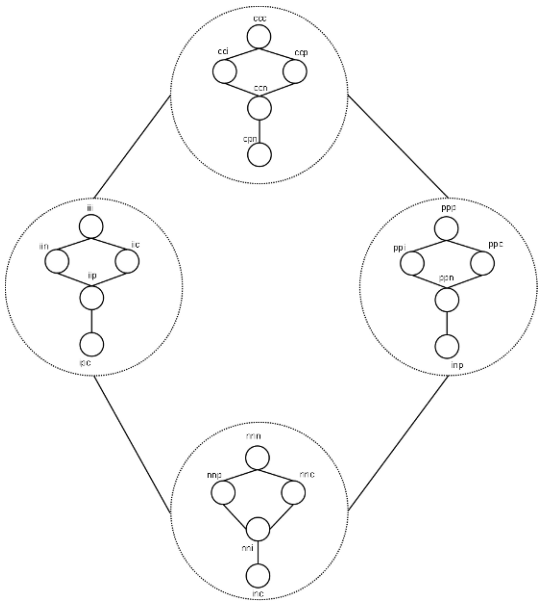


Fig.9. Nested lattice

On Fig. 10 we show in details how the twenty answer combinations from Fig. 9 are related. Any two nodes except *ccc*, *iii*, *ppp*, and *nnn* in the lattice on Fig. 9 connected by an edge differ in exactly one answer.

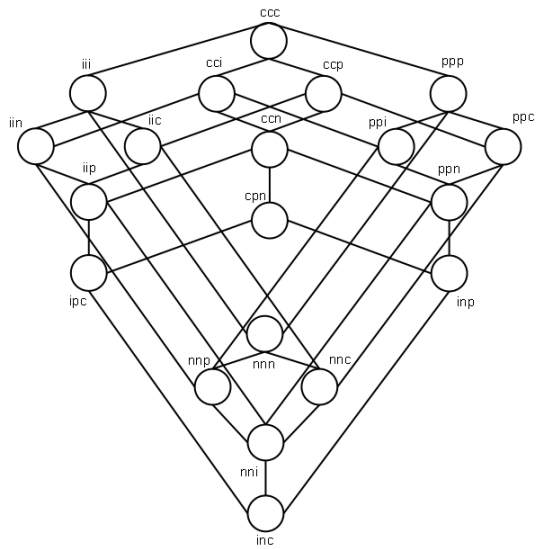


Fig. 10. Relations among corresponding truth values

The four nodes *ccc*, *iii*, *ppp*, and *nnn* are connected since they correspond to the four truth values in Belnap's logic.

IV. SYSTEM IMPLEMENTATION

The three tests' questions of a particular assessment are randomly taken from a pool of questions related to a particular skill. Within the options following each question, there is only one correct answer. Each question can have more than one partially correct and/or incorrect answers related to it. Thus for each test with three options the system chooses randomly one partially correct out of the set with partially correct answers and one incorrect answer out of the set with incorrect answers. A student taking a test can only choose one of the presented options. It is up to the test designer to state which one is correct, partially correct or incorrect. An assessment is dynamically build at run time each time a student is accessing the assessment part of the Web site.

The system shown on Fig. 11 can be implemented as a typical three-tiers Web application server architecture. The presentation layer is handled by an Apache Web server. The logic layer is written in Python. The data layer is implemented using SQLite database engine. Python provides a programming environment for implementing script-based handler for dynamic content, data integration and users' software agents. The back end SQLite databases are used to store both static and dynamic data. Apache is a modular Web server that can incorporate a high level scripting language as a module such as f. ex. mod_python. Using mod_python, python interpreter becomes a part of the Web server. SQLite is a small footprint, zero-administration and serverless database system. SQLite stores persistence data into files. SQLite thus provides a database platform for multiple databases.

The separation of these units makes it possible to modularly design and implement the system as loosely couple independent sub-systems. Communication framework based on XML-RPC is used to connect the Web application middleware and the intelligent assessment/diagnostic system together. The system is composed of sub-systems, all of which can be written in Python.

The dynamic document publisher sub-system compiles a page to be presented to the user. How the page will look is defined in a template object in relation to the user response, current state variables and activities history. Documents and template objects are read from a common documents database. Tests questions data is read from a common tests database.

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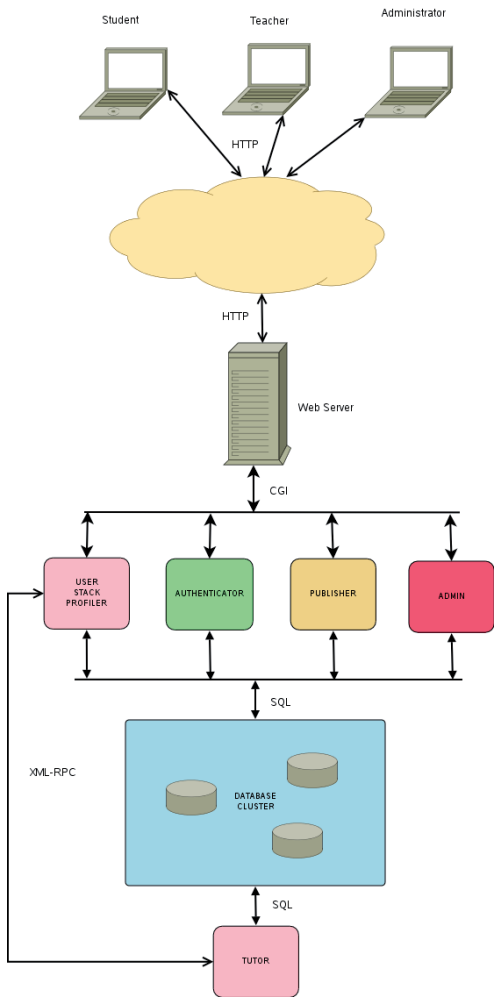


Fig. 11 system implementation

The authenticator sub-system authenticates a user during login and creates initial session contact in the system if the user provides correct credentials. This sub-system also provides user authorization during an active user's session and is also responsible for session cleanup at user's log off.

The stack profiler sub-system keeps track of user activities history in a stack like data structure in the user database. Each event, like for example response/result of a test or a change of learning flows after following a hint given by the system, is stored in this database. This sub-system provides the percepts to the intelligent tutorial sub-system. The stack profiler receives student's test responses and calculates the final result of the test. The stack profiler provides a user with immediate feed-back. Analysis of the user's profile is given to the tutor sub-system. This subsystem runs in different processes but operates on the same user database.

The tutor sub-system provides a student with intelligent diagnostics and the optimal study flow for that particular student based on her current profile. The hints and diagnostics are written into the user database. The stack profiler which is accessible by the user's browser reads the most recent messages from the tutor sub-system whenever hints or diagnostics are requested by the user. Using a rule-based method the tutor sub-system provides the student with the best study advice to facilitate students' progress in mastering new skills. Since the system is built on different sub-systems the independent sub-system can Be maintained and improved separately. These subsystems are operationally bounded with each other by the information stored in the multiple databases.

V. CONCLUSION

This paper is devoted to assessing students understanding of a concept applying automated testing procedure. Responses to three questions addressing one particular concept are used in the decision making process. This contributes to attaining higher level of certainty in the provided feedback. Employing many-valued logic for drawing a conclusion after a test is taken consecutively allows real use of student's previous tests results. Furthermore applying many-valued logic captures the complexity of students' responses much better than Boolean logic.

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mmeybodi@aut.ac.ir

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mmeybodi@aut.ac.ir

Usability Engineering of an Interactive Voice Response System in a Diverse-Cultured and Multilingual Setting

T.J. Ndwe
Meraka Institute
P.O. Box 395
Pretoria, 0001
South Africa
jamakasijadu@gmail.com

M.E. Dlodlo
Department of Electrical Engineering
University of Cape Town
Private Bag X3
Rondebosch, 7701
South Africa
Mqhele.Dlodlo@uct.ac.za

D.J. Mashao
Department of Electrical Engineering
University of Cape Town
Private Bag X3
Rondebosch, 7701
South Africa
Daniel.Mashao@sita.co.za

Abstract-**This paper advocates the utilization of user centred approach in the design of the user interface (UI) of a speech-enabled interactive voice response (IVR) system for the provision of information to the diverse user population of Southern Africa. It is postulated that the end-product of this research will allow users to access information through a telephone line in their language of choice amongst the various official languages of South Africa and will therefore benefit all the citizens of the country including those with low literacy levels and little or no experience with contemporary ICT.**

I. INTRODUCTION

The need for access to information and communication is almost as important as food, shelter and health care needs in any population group. More importantly, developing countries need to access information and experience from developed countries. This will not only uplift living standards there but promote collaboration through global connectivity and information sharing.

In developing countries it is difficult for most people to access information because the tools and the technologies for access such as computers and the internet, are prohibitively expensive and require training prior to using such technologies. This bars those who are either poor, illiterate, or without any computer skills from accessing information and unfortunately they are the majority of the people living in the underdeveloped areas of the world, including South Africa. The inability to access information and participate in the global information economy brings about new forms of social injustices through social exclusion and marginalisation.

The people of South Africa speak eleven official languages and vary widely in terms of their educational, socio-economic and literacy backgrounds. These differences contribute to the huge information gap that is created by, amongst other things, the inability of the masses of South Africans to access information. Also, this divergence makes it a challenging task to design a technology user interface that will suit all due to the aforementioned differences.

Current information technologies that are readily available and familiar to the people in the envisaged deployment area of Southern Africa include radio and telephone. For example, wireless radio is such a technology because throughout Southern Africa, the majority of households have a radio. The drawback of this technology is that it is a one-way communication device and therefore it cannot be interactive and the user cannot choose the specific information that they want. Another viable option is the telephone, which is an instrument that the majority of people are accustomed to and have used at some time. There is no prior training necessary for the majority of people to make a telephone call. In addition to this, it is estimated that there are 3 personal computers for every 1000 people in sub-Saharan Africa [1], which accounts for less than 1% of the population of Southern Africa; whereas 42.4% of households in South Africa have access to a land-line and/or cellular phone [22]. Furthermore, the number of cellular phones is growing rapidly in the region.

Another rationale for telephonic information access is the fact that speech is the fundamental means of human communications [12]. Speech is so much a natural channel for communication such that hearing people in all cultures persuade, inform, and build relationships primarily through speech [16].

According to Sections 30-32 of the Bill of Rights of the Republic of South Africa, it is stated that citizens have the right to access any information held by the state in their language of choice and have the right to form, join and maintain cultural, religious and linguistic associations and other organs of civil society [21].

This research looks at how telephonic communication can be used effectively and satisfactorily in order to access information by the diverse-cultured user population of South Africa through the use of speech recognition-enabled interactive voice response (IVR) system. The research is motivated by the aspiration to address the existing condition of social exclusion through

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 554–559.
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marginalisation of the people who could benefit immensely from the provision of relevant information that could positively affect their livelihoods, but who are barred from such information by their economic and social circumstances. The research looks primarily at the usability of telephonic voice access as a feasible means to extend the capabilities of ICT to include those who do not have the tools and/or the know-how to access information using the contemporary tools such as computers and the internet.

The information to be accessed is primarily governmental services such as information on applying for a driver's licence, health services, obtaining a birth certificate, social benefits and so on. As a positive consequence, this approach in accessing information can also be used by the marginalised community of the blind.

II. Objectives and Goals

The first objective of this research is to investigate the most appropriate aspects that need to be addressed when designing a user interface (UI) for a speech recognition-enabled IVR system in a setting with varied cultures, social backgrounds and languages as that of South Africa.

> *Good design improves the usability of voice services – it reduces overall development costs and the time to roll-out by eliminating problems early in the design cycle* [23].

The information obtained from such a study can be used to enlighten technology evaluators of IVR systems, within the context of diverse users, in assessing the right entities rather than dissipate time and resources by measuring the inappropriate variables. Evaluation of the correct variables in the interaction between the system and the users will in turn foster a better product or service from the design engineers, and thereby keep the users of the technology satisfied and happy. Keeping users satisfied is one of the main aims of user-centred design (UCD) and the usability engineering field in general.

A secondary objective of this project is to produce a high level framework of what an appropriately-designed UI for an IVR system should be in order to meet the needs of a diverse user population as in the context of this research.

One of the questions to be answered within the given context of multi-faceted user population is whether it is more feasible to use content translators or to use pre-recorded voice responses and when it is more applicable to use the other over the other. Other considerations include whether it is better to use a male or female voice, whether to use feminine or masculine voice, extroverted or introverted voice, and other considerations that are part of the system dialog design in the UI. The dialog design is often the key to a successful IVR system [23].

> *Experience has shown that there are major benefits to be derived from a good human interface design and that this can have a significant impact on the commercial success of automated telecommunications products* [5].

Mere translation of content into the different languages that are used in the target area does not serve the purpose of meeting all of the usability needs in such a setting. Localization of content within the different languages and cultures also includes other facets such as the mental models of each user group, acceptance and familiarity with certain metaphors, perceptions, and so on.

> *To successfully build bridges between worlds, user interface designers must increase their awareness of cross-cultural differences…Creating fluent interfaces for international markets goes beyond translating text and date, time, and number formats* [18].

Other factors such as learnability, effectiveness and user satisfaction also need to be taken into account in the design of an interactive system, and therefore, this research study will have to put all those components of usability into perspective so as to produce a formidable solution. It is important to ascertain that the user experiences minimal anxiety during interaction with the system through a natural voice interaction and an interface that is not prone to error.

> *Natural language relieves the burden of learning syntax* [20].

The information acquired from investigating the first and second research objectives posed above can then be used in formulating a method or framework, which can be used by both designers and evaluators of the UI of such a system for the rapid development and evaluation of the UI of such a system. This is the main objective and goal of this research. The envisaged strategy in order to meet this goal is through the usage of a few case studies of applications in developing systems that deliver information and services such as health services and educational information. These case studies are applications that will be developed at the Meraka Institute at the Council for Scientific and Industrial Research (CSIR) in South Africa.

It is envisaged that the lessons learnt and the experiences gathered will enable this research to reach its research through comparisons of user behaviour data between the different applications. There will be field visits to observe target users in their environment where the potential users will be engaged in usability evaluations, conversations, interviews and observations. The usability engineering of each system's UI is aiming

mmeybodi@aut.ac.ir

at discovering at least 80% of problems with each UI. Achieving the goal of 80% discovery of usability problems in each UI will depend on the number of test users deployed in the usability studies. In general, the hypothesis that is being tested in this study is the proposition that ignoring cultural aspects and the social environment of the users will lead to ineffective UI design and hence an unsuccessful system.

III. Principal Issues, Problems and Controversies

In order to put things in perspective and to illustrate the abilities or inabilities of the IVR system, there will be a constant comparison between the speech-recognition based IVR system that is under investigation in this project, and its predecessor, the touch-tone system that uses DTMF tones. This is done in order to determine whether a DTMF system has any advantages over the voice-enabled system. Conceivably, the ideal system for the envisaged deployment area is a hybrid of both aforementioned systems, and this research will address the issue of a hybrid solution. This means that the research will have to establish as to when it is best to use the touch tone system and when it is best to use speech-recognition based IVR system when the two systems are blended together into one system.

> *Blending of interaction styles may be appropriate when the required tasks and users are diverse* [20].

There have been some usability tests of a voice-enabled IVR whereby the users were asked to compare the two modalities of input systems, but those studies have been done in the USA, with users who are mostly fluent in English in a country with a homogeneous official language. Results of such studies, conducted by Harris Interactive and commissioned by Nuance, have shown that speech-enabled IVR systems are more preferred by users more than the touch-tone system, citing ease-of-use, convenience, and accessibility as the key benefits in using the speech-enabled system [15]. The use of voice-enabled IVR is touted to be very effective in call-centres and very cost effective [19].

By virtue of human evolution, people have become so voice-attuned so much that when humans hear any voice they quickly associate that with people whether the source of the voice is man or machine [7]. Through extensive research it has been found that humans respond socially to all voice interfaces whether the voice origin is of man or machine. In fact, humans use the same parts of the brain to interact with machines as they do to interact with humans and because of this phenomenon designers can tap into the automatic and powerful responses elicited by all voices, whether of human or machine origin, to increase liking, trust, efficiency, learning, and even buying [12].

IV. Theoretical Framework and Research Positioning

This research study is conducted within a field of engineering, but it is heavily influenced by social sciences in the sense that it is a study of how human beings interact with a particular technology with the desire to improve the design of the technology so that it serves its users more fittingly. The study is aimed at emancipating the users and enhancing their livelihoods through provision of information and services in their own native language by means of the use of a familiar technology rather than a novel technology that needs to be learnt and mastered before users are able to use it. Engineering is a field that is mostly dominated by empirical approach in research, which relies heavily on measurable and observable facts and based on knowledge as exclusively a function of experience rather than hearsay, rumour, doctrine, intuition or imagination [8]. This particular research would be limited and incomplete if it was to take the empirical approach alone, because "there are still things that you cannot measure" [11]. This is particularly so in studies which are concerned with human behaviour and the improvement of quality of life.

The research recognises the cultural differences between the various peoples of South Africa and attempts to provide a technological solution that is aligned with their cultural contexts in the hope that this would bring more effective interaction between the user and the technology, thereby enhancing user satisfaction. The main cultural aspect to be considered in this study is that of language since the UI of the technology under investigation is speech orientated. Other cultural aspects to consider would be the differences in usage statistics and varied user preferences such as the partiality towards the use of male or female or both genders' voice amongst the different languages.

> *User interface design requires a familiarity with the cultural and economic context of the user. As a whole, people who have never learned to read or write are poorly understood by researchers and developers of technology* [17].

In other words, the project attempts to design a technology according to the users' needs and expectations rather than from the novelty and functionality of the technology as perceived by the designers. This allows the users to participate in the design of the technology that will eventually be used by them, which is a way of empowering the user to produce tools that will be used by self. This enables the target users to actively participate in the information economy at first hand rather than hear about the so-called 'information age' and not knowing what that means.

> *Historically, society has seldom given poor people ownership over the tools of production* [4].

mmeybodi@aut.ac.ir

The research takes a viewpoint of empowering and emancipating the users rather than the stance of commercial viability, which is a perspective that is taken by most usability studies which have been conducted in the more affluent western countries.

A positivist framework stance underlies and dominates the project since the knowledge interest is of technical nature with an anticipation to tackle a social problem (the information divide and social exclusion) in a predominantly technical manner.

V. Research Area and Research Population

The key components in usability testing are: representative tasks, representative participants (test users), and representative environments, with the test users' activities being monitored by one or more observers [2]. The research aims to eventually include all of the people of South Africa, with all the official languages of the country. Since it is not fiscal to do this with all the different languages in South Africa within this one research, the project will focus on three initial languages namely Xhosa, English and Setswana. The rationale behind this choice of languages is that they are selected from groups of mutually intelligible languages, which are languages whereby speakers of any one of them can readily understand all the others without intentional study or extraordinary effort [25]. For example Xhosa, Zulu, SiSwati are all Bantu languages and are mutually intelligible, which minimises the need to select more than one language in such a group of languages for the purpose of this research.

Participants who are fluent speakers of those three languages will be used in the research as a sample for the research. It is estimated that at least 15 subjects from each language group will be recruited, yielding a total of at least 45 subjects per iteration. Early studies in the number of users that should be used in conducting usability experiments, conducted by Virzi and later by Neilsen, have suggested that 5 test users per iteration can reveal an average of 80% of all the usability problems that exist in a UI [24] and 14]. The problem with the assumptions made by Virzi and supported by Nielsen is that the range of problems revealed can be anywhere from 55% up to 99% [6], which implies that there is a possibility that almost half of the usability problems can be missed, which would not be a good usability exercise and would certainly not qualify for this study as the research aims at uncovering at least 80% of the usability problems in the UIs of each system. In a usability study conducted by Faulkner whereby 60 users were tested and random sets of 5 or more were sampled from the whole of 60 in order to demonstrate the risks of using only 5 test users and the benefits of using more, it was found that the range of usability problems that were uncovered for 5 test users was 55% to 99% with an average of 80%; for 10 test users the minimum value of the range was increased to 82% with an average value of 94%; and for 15 users the minimum value was increased to 90% with an average value of 97% of problems being uncovered [6]. The experiment clearly showed the benefits of increasing the number of test users for any given iteration. The common barring factor that usability professionals usually encounter in recruiting more test participants is that of budget constraints from the funding company [6]. In the case of this study the test users are the people who will eventually be using the systems developed and therefore the study qualifies as an emancipatory, participatory research whereby the test users are low-cost audience of participants. It is expected that the tests users will be very eager to participate in the experiments so much that there will be an overflow of enthusiastic test participants as opposed to a shortage of test users due to funding constraints, because the test users will be informed that the system to be developed will be of benefit to them and used by them. The figure of 15 users per iteration will be more than essential in meeting the goal of uncovering 80% of the usability problems. The 15 users per iteration will ensure that even in worst scenario, at least 90% of the usability problems will be discovered.

Each participant will be interviewed in their own language out of the three languages mentioned above and all experimental conversations between the system and the users will be conducted in their fluent language of choice out of the three languages that have been chosen for this research.

VI. Development Relevance to South Africa

A telephone is publicly available in many places and requires no particular skills to operate. If this familiar technology can be used to access information, it can help in bridging the information gap that exists in South Africa. This research study is envisaged to have an impact in reducing the gap and marginalisation that has been discussed in the introductory paragraph. The research will benefit the marginalised communities, i.e., those who are technology illiterate and those who have disabilities of sight. People may no longer need to travel distances in order to obtain simple government services. It will also enable the government to serve its citizens more adequately and reduce the overcrowding and queues that are typical of government service offices in South Africa. The research will also reduce the effect of the information divide by enabling the country as a whole to have its citizens participating in the global information economy thereby producing more jobs for the people of the country.

The research output can also be applied in the entire developing world, and particularly in Africa, which is in accordance with the New Partnership for Africa's Development (NEPAD) and the African Union (AU) initiatives. These 2 programs are both aimed at political, social, and economical development that seeks to pull the entire continent out of the quagmire of poverty, underdevelopment and marginalization. It is important to

mmeybodi@aut.ac.ir

have this broader vision of development of Africa as whole, because there cannot be true development in South Africa unless there is development for all the neighbouring countries and ultimately all of Africa.

It is well documented that ICTs have the capability of accelerating development. A human-centred approach to ICT will help in making sure that the technology that is used is truly usable and accessible to all including those who have been previously disadvantaged and have not had any exposure to ICTs. This will help the South African government and other governments throughout Africa to ensure the development of more effective ICT sector strategy and policy framework in order to harness the potential of ICTs so as to guarantee better governance, deepen democracy and accelerate growth and development, especially job creation and poverty alleviation and in so doing, create an information society that improves the quality of life for all citizens.

VII. Research Methodologies

In this research study there will be a variety of research methodologies that will be used to provide both qualitative and quantitative information about the interaction between the users and the system. This information will be used to understand the user, the user's interaction with the technology under investigation, the tasks that the user performs, and the social and environmental influences on users and their tasks. The driving force behind this multifaceted research approach is harmonious with the old saying that, "the more, the merrier", and also because "any system of ideas has both strengths and limitations and if [only one is] followed to the exclusion of all others, [that] creates problems" [8].

The various research methodologies will each address a different issue because there is no research methodology that is a one-size-fits-all and universal to all HCI research. Each method is strong in addressing a particular investigation and is insubstantial in addressing another issue, and therefore a more comprehensive research study is one that is made up of different research methods.

It is imperative to utilize user needs assessment and task analyses methods because the user is central to this investigation. These methods involve task analysis, contextual inquiry, and cognitive walkthroughs by means of interviews and questionnaires (collectively known as survey methods) that will be conducted in conjunction with the subjects in the sample. The combination of these tools and methods will shed light and provide valuable information to the one of the objectives of the research, which is to investigate the most important aspects that need to be considered when evaluating the system. In turn the knowledge obtained from such research can be used to foster the second objective of the research, which is to provide a framework of what a well-designed IVR system should epitomize in order to meet the needs of a diverse-cultured user population as that of the envisaged deployment area. From these two objectives, the primary objective of a method for investigating the usability of an IVR system in a multifaceted context will be developed. As an example, learnability of the system is one of the factors that need to be taken into consideration in the features of the system, because the users need to be able to easily learn the operations of the system so that they can eventually spend less time interacting with the system whilst getting the appropriate content from the system usage, i.e. getting more for less, thereby maximizing the efficiency of the system. This part of the research can be attained through the utilization of a survey method such as a cognitive walkthrough, which primarily scrutinises how certain characteristics of design may weaken or enhance the learnability of the system for the user.

The study involves the observation of how different user groups interact with a particular technology within their cultural context. A culture can be defined as being "…made up of certain values, practices, relationships and identifications" [10]. These variables that constitute each culture make each culture to be unique in its understanding of the technology and hence unique in its user needs. This part of the research will be addressed by utilizing ethnographical research methods, which will enable the researchers to gain a naturalistic view from each user group's point of view.

In order to address a framework of a well-designed IVR system, the envisaged system has to meet with and abide by with some generally accepted rules of a usable interface. This can be done by using heuristic evaluation methods, which "helps evaluators focus their attention on aspects of an interface that are often sources of trouble, making detection of usability problems easier" [3]. Also by following these generally accepted heuristics, more knowledge can be discovered about which aspects are of most importance in the evaluation of an IVR system in the given setting. Again, this will provide information and foster the objectives of this research study. The heuristic method is also suitable for this evaluation in the sense that the method "…can be performed on user interfaces that exist on paper only and have not yet been implemented", [13].

As the research is aimed at allowing the users to be active participants in the design of the technology that will eventually be used by them, this research uses elements of emancipatory action research. The researched subjects will be empowered to have a feel of being on the information highway and the tools to do so will have been partly developed by themselves.

> *Research and development efforts in the field of IT for developing regions suggest that involving community members in design and creation ensures that proposed solutions meet the needs of the community and provides the best chance*

mmeybodi@aut.ac.ir

of sustainability of technology in a community [17].

It is important that the target users are involved and actively participate in the design of the technological solution to be used by them for information access and this should include the consideration of their social and cultural characteristics in order to make certain that the proposed solution is effective and efficient in enhancing the target people's livelihoods [9].

This research will also contribute in disseminating information on the most appropriate research methodologies or any combination thereof, which one needs to employ in the study of diversified settings for the interaction between users and technology.

ACKNOWLEDGMENT

We would like to thank the continued support of the Meraka Institute, National Research Foundation, and the Centre of Excellence in this project.

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mmeybodi@aut.ac.ir

The Integrated Education of Transportation Engineers in Fields of Computer Graphics, Descriptive Geometry and Technical Drawings

Marjan Lep, Sergej Težak
University of Maribor
Faculty of Civil Engineering
Smetanova 17, 2000 Maribor, Slovenia
lep@uni-mb.si, sergej.tezak@uni-mb.si

Abstract: **The application of computer graphic methods, particularly dynamic analysis of images like automatic vehicle classification (AVC), automatic vehicle identification (AVI) thru automatic license plate recognition (LPR), automatic incident and accident detection (AID), monitoring and characterization of linear traffic flows (road traffic) or stochastic traffic movements (pedestrian movements, ski slopes) etc. is widely spread in the transportation engineering and is becoming more and more important.**

On the other hand, the classical way to present and express vector based technical information, like construction of projections, shading, design of curves etc., are still required in the engineering practice and the classical contents of descriptive geometry is still needed. The conversion from raster image into vectorised objects is the most important process in the transportation engineering practice (pattern recognition, character recognition, recognition of objects, assessment of object movements etc.)

On the basis of an analysis of study programs in European faculties we established that in the education of transportation engineers there are separated lectures of:

- **descriptive geometry and technical drawing (with predominantly vector approach),**
- **computing, informatics and computer graphics (with predominantly raster graphic approach).**

The article presents a new model of integrated education of transportation engineers in which geometric and graphic contents are united.

I. INTRODUCTION

Traffic circulation and planning are nowadays gaining in importance as they present the key for linking people and world economy. This is especially important in the present state of globalization because the level of traffic growth in urban and rural environments has surpassed all predictions. The use of modern technologies for traffic surveillance and monitoring is therefore indispensable.

Within this frame, the role of a transportation engineer in transportation planning and traffic circulation has been greatly increased. It is therefore indispensable that a transportation engineer understands and masters the latest technologies for monitoring, surveillance, management and control of transport. Today, the process of a dynamic analysis of raster images is used for determining the conditions on traffic routes together with the vectorisation of raster images to obtain key parameters of traffic circulation.

Transportation engineer should necessarily obtain this knowledge already during their studies although they will have to keep abreast with the latest technologies and get out of job training to maintain themselves in an increasingly competitive labour market. Transportation engineering study programmes have been up to now designed so as to provide separate lectures in descriptive geometry and technical drawing and separate lectures in information and computer science. Besides this, there were separate lectures in technologies for monitoring, surveillance, management and control of traffic in the last two years of studies. The students learned each chapter separately without being aware that the lectured problems form a whole from geometry to the usage of technologies.

II. TRAFFIC ENGINEERING TECHNOLOGIES WHICH USE RASTER IMAGE ANALYSES

For tracking, controlling and regulating traffic technologies that work on the basis of raster image processing are being increasingly applied. This technology is applied as automatic vehicle classification (AVC), automatic vehicle identification (AVI) thru automatic license plate recognition (LPR), automatic incident and accident detection (AID), monitoring and characterization of linear traffic flows (road traffic) or stochastic traffic movements (pedestrian movements, skiers on ski slopes).

The same technology is also used in vehicles as a road vision system that supports drivers with detecting critical driving conditions.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 560–564.
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mmeybodi@aut.ac.ir

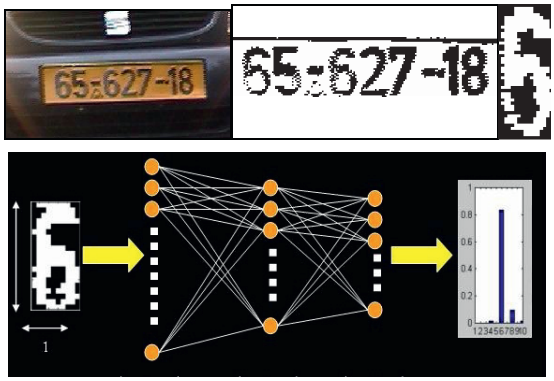


Fig. 1: Licence plate recognition using the method of neuron networks (principle) [1]

A dynamic analysis of raster images is based on raster images taken in time intervals and used for calculating dynamic parameters of objects being observed. This is the technology of »image processing«, which is used for the recognition of objects on a photograph.

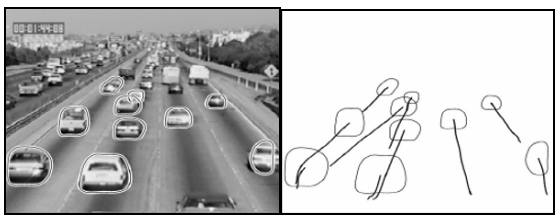


Fig. 2: Object movement recognition (schematic view) [1]

This is the basis for determining the direction and speed of vehicle movements. If several subsequent images are analysed, the speeding or breaking of a vehicle can also be ascertained.

Figure 2 shows an example of road vehicle movement recognition the vehicles all moving linearly in the same direction (with the exception of changing the lane). There are fewer problems in determining the speed in this case.

When stochastic movement has to be recognized (pedestrians and skiers on the slopes), that is when subjects move in different directions and with a different speed, the methods for determining dynamic properties of these subjects are more complicated. When the surface on which the subjects move (for example skiers) is not level, a digital model of the area must be used to establish dynamic properties of the subjects. [4]

The working principle of such a system is based on the recognition of the projection coordinates of the subject on the photograph which correspond to the coordinates on a 3D model of the surface on which the subject moves (as accurate geodetic snap as possible). An example of such a system is shown in Figure 3 for which the coordinates of the 3D model of the area have been entered into the computer. The system must be calibrated which means that the point on the area in nature must be given by calibrating the coordinates x_p,y_p on the image or projection respectively. Each point on the photograph has simultaneously a point on the 3D model of the area.

To determine the movement along an uneven surface, we project the point from the reality onto the raster image, determine the projection coordinates of this point (x_p,y_p) and calculate the coordinates of this point on a 3D model of the area (x,y,z). This means that the real coordinates of a subject on the 3D model of an area can be fairly accurately determined with the projection coordinates of the subject on a photograph.

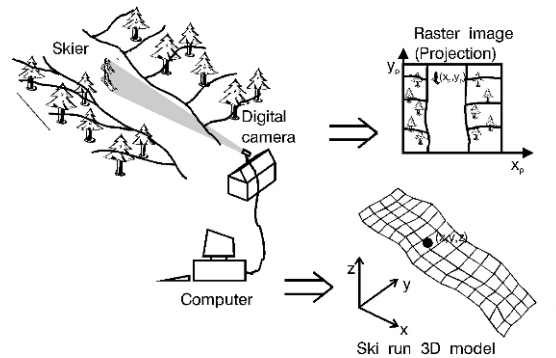


Fig. 3.: Monitoring skiers by means of the dynamic visual-computer system [4]

If this process is repeated in determined time intervals, the change of the subject's position on the image (photograph) can be determined and consequently the change of the position on the 3D model of an area. The speed of the subject can so be determined. Using powerful computers that quickly analyse the images (projections) and determine the position of subjects on the photograph and on the 3D model, we can determine the subject's direction, speed, acceleration and loading during movement.

III. COMPUTER GRAPHICS AND DESCRIPTIVE GEOMETRY IN THE EDUCATION OF TRANSPORTATION ENGINEERS

Within the frame of new study programmes which are being introduced at the Faculty of Civil Engineering we compared different university and higher professional study programmes of traffic engineering at different European universities and higher schools.

A. Bachelor university study programmes of "Transportation Engineering"

The Bachelor university study programme is designed according to the statement obtained from the analysis of

mmeybodi@aut.ac.ir

comparable study programmes of Traffic or Transport Engineering offered by faculties of transportation and civil engineering (transportation engineering) in Europe.

Several European top study institutions run Transportation engineering study programmes on the principle of 4+1 years. We found out that their programmes and the programmes of 3+2 years, regardless the duration of study, have a comparable average of basic mathematics-natural science knowledge and basic professional knowledge.

For the comparison we selected the below study programmes:

- TU Dresden, Fakultät für Verkehrswissenschaften "Friedrich List", the program Verkehrsingenieurwesen (4 years)
- Slovak University of technology in Bratislava, Faculty of Civil Engineering,the study programme: Civil and Transportation Engineering (3 years)
- Budapest University of technology and economics, Faculty of Transportation Engineering, program Transportation engineering (4 years)
- TU Berlin - Fakultät für Verkehrs- und Maschinensysteme, Studiengang Verkehrswesen, (4 years)
- TU Graz - Fakultät für Bauingenieurwissenschaften, Bakkalaure studium Bauingenieurwissenschaften (3 years)

TABLE 1
Results of comparison between the new Bachelor university study programme of Transportation engineering and other study programmes [3]

Field of subjects	FG UM	TU Dresden	SUT Bratislava	Budapest UT	TU Berlin	TU Graz
	ECTS	SWS LP	Cr ECTS	Cr ECTS	SWS	ECTS
Mathematics	17	21 (31,5)	22	16	20	15
Statistics	5			4		
Physics + kinematics and dynamics + electrical engineering	8	13 (19,5)	6	13	4 (1)	8
Chemistry		4 (6)				
Geometric modelling with CAD & Descriptive Geometry	7		5	9(2)	18(3)	5
Computer and Information science	7	7 (10,5)		6	4	9
Geography	4	4	4		4	
Transportation systems	5	6	2	6	4	
Geodesy	4	3 (4,5)	5			
Engineering Materials	7	6 (9)	5	10	6	6
Technical mechanics + geotechnics + hydrotechnics	17	5 (7,5)	22	15	18	52,5
Transport economics	7	4 (6)	10	10	8	9
Transportation Law	3	3 (4,5)	4	2		
Transport ecology	5	4 (6)	5			
Vehicles (driving dynamics + engines)	6	19 6		11	16(5)	
Engineering structures	5		30			33,5
Transportation infrastructure (designing, construction and maintenance)	12	6 (9)	9	8	8	6
Transportation planning	6	12 (18)	5	10	16	
Traffic flows theory	6	5 (7,5)	5		4	
Urban and regional planning	3	6 (9)	4		8(6)	11
Transport technology	6	4 (6)		7	8	
Foreign language	3		8			
Traffic safety	4	2 (3)		2		
Transport infrastructure management	4			5	8	
Transportation informatics and telematics	5			6	4	
Optional subjects	18		5		26	15
Bachelor's thesis (thesis seminar)	3	0(7)	2	20	0(7)	10

B. Bachelor high school study programme of "Transportation Engineering"

The Bachelor high school study programme has been designed according to the statement obtained from an analysis of comparable study programmes of Traffic or Transportation engineering offered by higher schools in Europe.

For the comparison we selected the below study programmes:

- Fachhochschule Erfurt , study programme Verkehrs und Transportwesen (4 years)
- Fachhochschule Technikum Wien, programme Intelligente Transportsysteme (3 years)
- Veleučilište u Rijeci, Stručni studij cestovnog prometa (3 years)

TABLE 2
Results of comparison between relevant bachelor high school study programmes [3]

Field of subjects	FH Erfurt	FH Wien	VEL. Rijeka	FG Maribor
	ECTS	ECTS	ECTS	ECTS
Rudiments of transport	2	7,5		
Mathematics	5	15	8	10
Physics	5	7,5	4	4
Statistics	2,5		4	4
Engineering Materials			5	6
Foreign language	5	15	13	3
Computer and Information science	10	10,5	10	8
Transportation informatics	5	3		3
Transportation systems	7,5	6	6	7
Technical mechanics	5		6	5
Traffic flows theory	7,5		4	5

mmeybodi@aut.ac.ir

Field of subjects	FH Erfurt	FH Wien	VEL. Rijeka	FG Maribor
Transport economics	17,5	4,5	14	14
Transportation Law	7,5	3	4	4
Geography	2,5	3		4
Quality management	4	3		3
Vehicles (driving dynamics + engines)	4 (optional)	3	6	7
Traffic safety			3	4
Transportation infrastructure			3	7
Transportation telematics	5	21	3	7
Logistics	12	3	18	7
Public transport		1,5	3	4
Transportation technology			4	4
Urban planning		4,5	4,	8
Ecology	3		3	7
Optional subjects	10		3	15
Practicum	30	18	2	18
Bachelor's thesis (thesis seminar)	30	3	17	12

C. Short analysis of lecturing chapters from descriptive geometry, technical drawing, information science and computer science

It is evident from the above tables that descriptive geometry and technical drawing, sometimes also CAD, are taught at the university level in the first year in all comparable study programmes. Computer graphics which contains chapters about raster images is taught within the subject Computer or information science in later years. In later years, too, chapters about technologies that use raster image processing are taught within the subject Traffic informatics and telematics.

In higher professional programmes there are no subjects taught at comparable higher professional schools that would include chapters from descriptive geometry or technical drawing. Other subjects are the same as in the university programmes.

To understand the working of applications which use computer graphics, especially dynamic raster image processing for monitoring, surveillance, management and control of traffic, students need to have the knowledge from geometry (projection, transformations) and computer and information science (recording of raster images, basics of programming). These chapters are taught separately in all study programmes or are not taught at all. In higher professional study programmes, however, students do not get enough knowledge to understand these problems (there is no subject Descriptive geometry or Technical drawing). Another problem is that for the needs of computer graphics the subject Descriptive geometry does not provide enough knowledge about analytical geometry which is the basis for programming. Classical descriptive geometry is more a basis for classical technical drawing ("with a ruler and compasses") while CAD programmes require knowledge of analytical geometry (transformations, projections …)

To handle these problems the Faculty of Civil Engineering introduced, some years ago, the subject Geometric modelling, which contains chapters from descriptive geometry, technical drawing and CAD. This subject will be also lectured in the new Bologna programmes of Traffic Engineering, both university and higher professional ones.

IV. GEOMETRIC MODELLING COURSE RESULTING FROM THE MERGING OF DESCRIPTIVE GEOMETRY AND TECHNICAL DRAWING AND INFORMATICS AND COMPUTER GRAPHICS.

The subject of Geometric modelling within the study programmes of Traffic and Civil Engineering at the Faculty of Civil Engineering contains chapters form geometry (analytical, descriptive geometry), technical drawing and basics of computer graphics and its use in traffic and civil engineering.

The fact is that design of engineering structures has greatly changed owing to an increasing use of computer graphics, such as drawing plans with CAD programmes, where vector graphics is mostly used. The development of computer science and high capacity computers have brought about an increasing use of raster graphics (as a basis for drawing plans and vectorisation with which input data for different applications in traffic engineering can be obtained.).

In the introduction to the subject the following notions are explained: model, modelling, geometry, geometric construction, geometric modelling, computer science, computer graphics, computer aided modelling and CAD tools.

Then follow the chapters from descriptive geometry, i. e. is construction with a ruler and compasses: These are: Construction of circle and tangent, Tangent on two circles (košarasta in kontra krivina), Transition curve between two circles, Ellipse and Tangent and ellipse.

The third chapter is the chapter from Geometric transformations which represent the basis for geometric modelling and computer graphics. First, geometric transformations are taught such as: Translation, Rotation, Scaling, Shear and Mirroring. These transformations are first taught in a plane and later in a space. They are calculated with the help of cartesic coordinates or homogenous coordinates. The chapter is concluded with Inverse transformations resulting form the change of the coordinate system.

The fourth chapter introduces Projections: Classification of projections and types of projections, Mathematical procedures as a basis of computer graphics (Perspective, Oblique, Parallel and Axonometric projection), Drawing of projections (Axonometric, Isometric and Dimetric projection, Orthogonal projection), Use of projections in engineering practice, and Standards in technical drawing.

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The next chapter introduces Computer graphics. Students are explained the notion of Computer graphics, Images in computer graphics, Differences between vector and raster graphics and Transformations (Vector-raster and Raster-vector), Data compression, Graphical data standards and functions, Data transmission, and Formats of graphical files.

The chapter about the basics of modelling solids includes basics of 3D modelling of solids. Analytical approach: Methods of polygonal plane meshes (Control points and Topology), Method of parametrical patches and Synthetic approach to the modelling of solids.
Methods of presenting solids: Wire-frame model, Solid model, Removing of hidden edges, Shading, Source of light (Point, Diffuse and Dispersed light); Characteristics of material, Reflexion coefficients, Ambient light, Methods of textures, Smoothing. Colours: Perception of colours, Recommendation for use of colours in engineering and transportation practice.

The last chapter is about the Ergonomics of graphic communication. Students get the knowledge of Standards, Form and Formats, Rules and Recommendations for graphic engineering documents (Proportions, Fonts and media …)

In the practicum students learn to use the above technologies, methods and procedures in practice using general CAD tools (AutoCAD, Microstation etc.) on a personal computer and on graphic input and output devices.

Within the subject Geometric modelling the above chapters provide students with basic knowledge from descriptive geometry, technical drawing, computer graphics and CAD tools. Chapters form computer graphics are especially useful to traffic engineers to understand up-to-date technologies, which work on the basis of raster images, transformation of raster images into vector graphics and key parameters that are obtained from raster images by a dynamic analysis of traffic (speed and density of traffic, vehicle type identification …)

V. CONCLUSION

Technologies which use a dynamic analysis of raster images determine the development trend in traffic engineering. Educational programmes for traffic engineers must therefore follow these development trends.

Chapters for understanding the technologies which use a dynamic analysis of raster images are taught separately at the European universities. Some students, but not all, get some basic knowledge by learning technical drawing within the subject of descriptive geometry and within the subject of informatics. Descriptive geometry is mostly lectured at engineering faculties to support technical drawing, whereas there are no subjects that would support the understanding of CAD programmes.

The subject of Geometric modelling, which was introduced at the Faculty of Civil Engineering, combines descriptive geometry and technical drawing (with predominantly vector approach) and computing, informatics and computer graphics (with predominantly raster graphic approach). This subject is needed by both civil engineers (understanding of computer graphics and CAD) and traffic engineers (understanding the working of traffic information systems).

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mmeybodi@aut.ac.ir

Demonstrations of Transmission Line Effects

Uma Balaji
California State University, Chico
Chico, CA 95929 USA

Abstract – A set of experiments on transmission line effects at high frequency has been described in this paper. They are measurement of impedance characteristics of resistors and capacitors at high frequency, determination of characteristic impedance and velocity factor of transmission lines and crosstalk measurements. Issues in design of analog/digital circuits at high frequencies are better appreciated by students when these experiments are performed.

INTRODUCTION

Research has continued to advance the operating speed of computers. The digital circuits in the computers are connected by transmission lines**.** Impedance mismatch between the source, transmission lines and load while operating circuits at high frequencies can result in loss of energy transfer from source to load causing the circuits to function differently than expected. It is impossible to design circuits where source, transmission lines and load impedances are always matched at all frequencies of use. The effects due to mismatch of the load and characteristic impedance can be studied by time domain reflectometry measurements as in [1]. This is done by sending a pulse on the line with its load mismatched and watching the reflected pulse due to mismatch. This gives an idea of the insertion loss of the line, velocity of voltage wave on line, characteristic impedance and other parameters of the line. Signal integrity has become important topics in design of high speed circuits. There are many websites that provide information to students on effects due to transmission lines using java applets [2]. Crosstalk between two adjacent lines is also simulated with animations [2].

However, presently digital design at high frequency demands time domain and frequency domain analysis. Laboratory experiments have been described in this paper to study some of the characteristics in frequency domain which can complement those suggested in references. One of them is study of high frequency behavior of passive components. A resistors or a capacitors included in the circuits tend to behave differently from their normal behavior at high frequency. A measurement of their impedance values over a large frequency range can show how they differ from the expected characteristics. The measurement of frequency domain characteristic of these components using impedance analyzer is presented here. Measurement of the characteristic impedance of transmission lines using the impedance analyzer is also presented. Transmission lines transform impedances at the load end to different impedance at their input at high frequencies. This can affect the behavior of circuit designed to operate at high speeds. Demonstration of impedance transformations through measurements is also presented here. This paper also discusses simple laboratory experiments to show effects due to capacitive and inductive coupling in transmission lines.

LABORATORY DESCRIPTIONS

A laboratory on high frequency behavior of resistors and capacitors requires impedance analyzer. An RF impedance analyzer, Hewlett Packard 4195A that measures component values from 10Hz to 500 MHz has been used here. Calibration of the equipment is required prior to these measurements. A standard short circuit and matched load are required for this. It is a good practice to calibrate before the experiment is performed as it affects accuracy of measurements. The frequency range of measurement is set on the equipment before calibration is begun. Impedance analyzers equipment provides a standard menu for calibration. A one port calibration is required and the equipment prompts to connect standard short, an open (realized by leaving the port open) and matched load. In order to connect resistors or capacitors, port extensions are used. The port extension transforms the coaxial line port to that with terminals for contacts where the resistor or capacitor can be connected. Since the calibration is performed at the coaxial port a correction factor for the length of the extensions of this port needs to be entered in the equipment

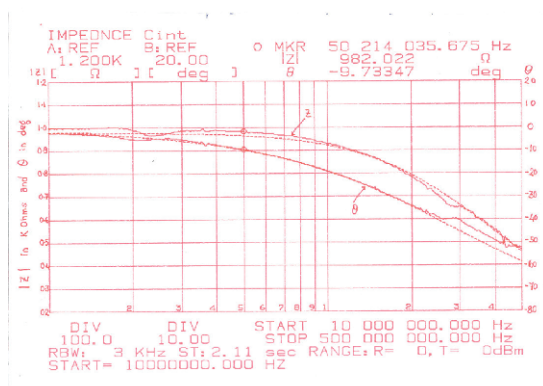


Fig. 1 High frequency behavior of Resistor
(solid lines - measured, dotted lines – simulated)

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 565–569.
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After calibrations are performed and the corrections have been done the component is connected on the port extensions. Keeping the leads of the components unclipped exaggerates the high frequency effect and is useful in demonstrating concepts on high frequency effects. Based on the impedance characteristics the equivalent circuit of the component can be obtained from the equipment along with its simulations. The inductance and capacitance from leads and other sources inside the resistor show that it behaves reactively at high frequencies. Fig. 1 shows this behavior of a resistor. The simulation of the equivalent circuit is shown by dotted lines while the actual measurements are shown by solid lines. The lead inductance of a capacitor can be large causing it to resonate. Fig. 2 shows this impedance behavior of a capacitor. The resonance due to lead inductance takes place at about 250 MHz. As an addition to this, students can be asked to build air core inductors by winding wires and the theoretical and experimental behavior can be compared.

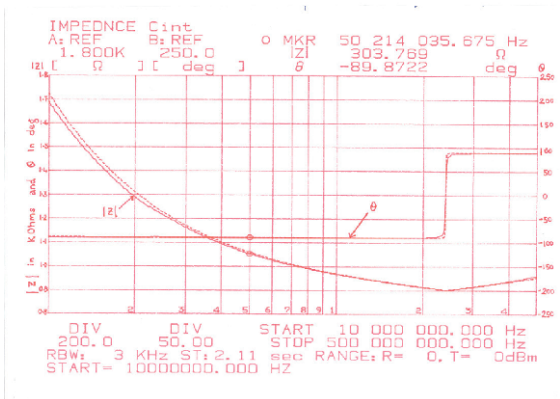


Fig. 2 High frequency behavior of Capacitor
(solid lines - measured, dotted lines – simulated)

A measurement of characteristic impedance of a coaxial cable can also be done on the impedance analyzer. In order to do this the equipment is calibrated in the desired frequency range of measurement. After calibration is performed a short length (length << wavelength at the measurement frequency) of coaxial cable is connected to the port and terminated by short circuit. Measurement of input impedance is done at a single frequency point with short circuit termination on the far end of the line. It is called $Z_{inSC.}$ Measurement of input impedance is repeated at the same frequency point with open circuit termination at the far end of the line and it is called Z_{inOC}. The characteristic impedance is obtained using the relation $Z_0 = (Z_{inSC}\ Z_{inOC})^{0.5}$. The inductance and capacitance per unit length of the line for a short length of line is obtained using the relations $L = \frac{|Z_{inSC}|}{2\pi f l}$ and $C = \frac{1}{2\pi f |Z_{inOC}|}$ where l is the length of the line. The velocity of the voltage wave on the line is obtained from $1/(LC)^{0.5}$. Measurements of input impedance on RG58U cable at a frequency of 15 MHz gave a value of $Z_{inOC} = 169.6\angle -90^{o}$ and $Z_{inSC} = 14.74\angle 88.6^{o}$. A characteristic impedance of 50 ohms is obtained by approximating Z_{inSC} as purely reactive.

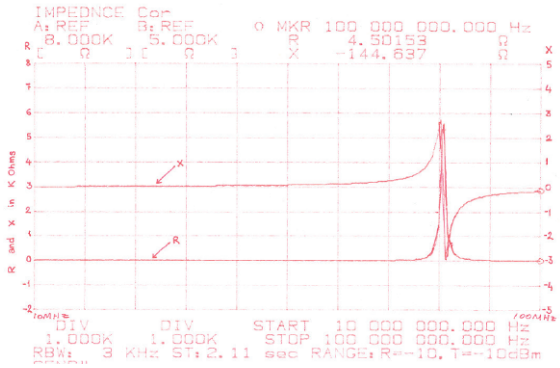


Fig. 3 Input impedance of a cable terminated in short circuit

The distributed inductance parameter L from these measurements was calculated as 246.22nH/m and capacitance of the line was 98.5pF/m. From the values of L and C the velocity of voltage wave, *v* was calculated as 2.03E8m/s. The measured input impedance of RG58U cable terminated by short circuit is shown in Fig. 3. The input impedance measured from 10 MHz to 100 MHz shows that it is very large and approximates that of open circuit around 80 MHz. The impedance analyzer plot shows both R and X. The value of R almost equals to zero (about 4 Ohms) at all frequencies except at 80MHz where the input impedance is that of open circuit with R approaching infinity along with X, meaning that the input impedance is infinity.

Analytically, input impedance of a line terminated by short circuit $Z_{in\,SC} = jZ_o \tan(2\pi f l / v)$ is purely imaginary. The measurements in Fig. 3 are verified with a plot from a simple MATLAB code as shown in Fig. 4. The input impedance approaches infinity at 80MHz as in Fig. 3 of measured values. This study can be extended by terminating a coaxial line or any other type of transmission lines with other values of impedance and measuring the impedance at the input end of the line. Analytically, the input impedance Z_{in} when a line of characteristic impedance Z_0 is terminated by an impedance Z_L is obtained from,

$$Z_{in} = Z_o \frac{Z_L + jZ_o \tan \beta l}{Z_o + jZ_L \tan \beta l}$$

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where $\beta = 2\pi f / v$ is the propagation constant of the line and is *l* is the length of the line.

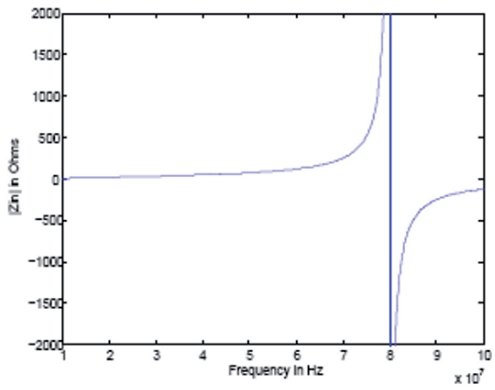


Fig. 4 The Input impedance (computed) of the cable in Fig. 3

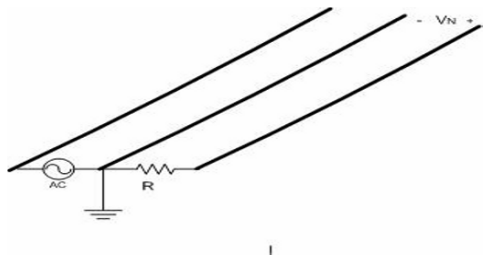


Fig. 5 Assembly of wires for determining capacitive coupling

Principles of crosstalk are fundamental to digital design at high speed and have been discussed in [3]. A simple experiment has been performed to gain knowledge on capacitive and inductive coupling in transmission lines. Capacitive coupling between lines is tested independently from inductive coupling. The set up consists of three wires of equal length laid parallel to each other at a known distance apart from each other as in Fig. 5. This layout can either be realized by laying small lengths of wires or easily obtained from three adjacent wires of a flat ribbon cable. The middle wire of the three wires in this set up is selected as the ground line although other lines can also be selected. The top and middle wire pairs are connected to source while the induced noise voltage between the bottom and middle wire pair is measured. The load ends of both pairs of wires are left open. While the top and middle pairs are connected to the source at the other end the bottom and middle wire pair is terminated in 1 KOhm resistor at this end. Capacitive coupling to the bottom and middle pair is tested by measuring the induced noise voltage at the open end while varying the frequency of sinusoidal excitation that is connected to the top and middle wire pairs. Due to the fact that the load ends of both two wire transmission lines are kept open, the current flowing on the lines is close to zero. Hence the coupling is assumed to be primarily due to electric field between the lines which means coupling is capacitive. The equivalent circuit as given in Fig. 6 of this configuration is thus due to the capacitance of the two wire lines. It is obtained by multiplying the capacitance per unit length of line by the line lengths used in the set up. The capacitance per unit length for a two wire line is given by C= $\pi\varepsilon / \cosh^{-1}(d/2a)$ where'd' is distance of separation between the two wires and 'a' is the radius of the wires [4]. For d/2a >3, C is given by C= $\pi\varepsilon / \cosh^{-1}(d/a)$. The capacitance per unit length of line for this configuration can also be measured using the impedance analyzer by following the procedure described earlier for a coaxial line. For flat ribbon cables it is usually specified by the manufacturer. The noise voltage V_N induced at the open end of middle and bottom wire pair can be calculated from the equivalent circuit as,

$$V_N = \frac{j\omega[C_{12}/(C_{12}+C_{2G})]}{j\omega + 1/R(C_{12}+C_{2G})} V_1$$

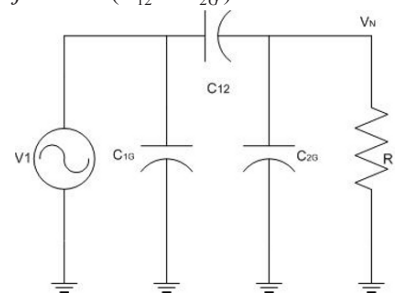


Fig. 6 Equivalent circuit of assembly in Fig. 5

In many practical applications $R << 1/[j\omega(C_{12}+C_{2G})]$ and the above equation is reduced to an approximate relation with $V_N = j\omega R C_{12} V_1$. From this relation it is observed that the noise voltage increases linearly with frequency.

Measurement was conducted using three parallel wires, about 15 cm long laid at a distance of 1.5 cm from each other. The induced noise voltage was measured from 100 KHz to 1 MHz. An oscilloscope was used in the measurement of induced voltage at the open end. It had an input capacitance of 25pF and resistance of 1MOhm. These two elements would be in parallel with the C_{2G}. This capacitance was also accounted for in the equation as it is of the order of the line capacitance. Hence C_{2G} is replaced with the parallel combination of C_{2G} with 25pF. The resistance R was a parallel combination of 1Kohm and 1MOhm. The theoretical and experimental values of induced voltage are shown in Fig. 7 and a reasonable agreement is found.

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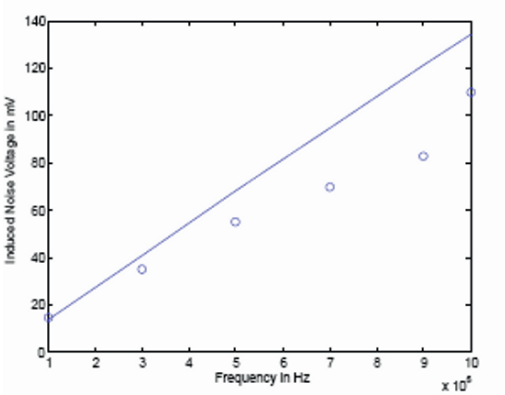


Fig. 7 Induced noise voltage due to capacitive coupling (solid lines - computed, dots - measured)

Inductive coupling can be studied by use of coplanar loop structures. Two loops of wires lying in the same plane are prepared with a certain radius. It is ensured that the loops are concentric and coplanar. One loop (loop 1) was terminated in a resistance and excited by sinusoidal excitation while the other loop (loop 2) was left open as shown in Fig. 8. Induced noise voltage in the loop that is not terminated or excited is measured.

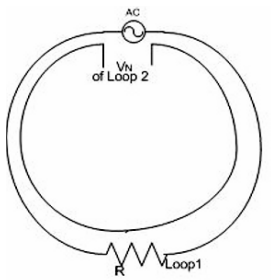


Fig. 8 Assembly of loops for determining inductive coupling

In this experiment circular loops are prepared although loops formed in a general PCB layout of circuits are rectangular. It is done so that the coupling is primarily due to inductance of the lines, rather than the capacitance between lines. The capacitive coupling can therefore be neglected. The inductive coupling to loop 2 from loop 1 can be obtained analytically from the mutual inductance between two loops $M_{12}= \phi_{12} / I_1$ where ϕ_{12} is the flux linking between loops 1 and 2 due to current I_1 loop 1. The voltage induced in a loop 2 is obtained from Faraday's law for a time varying current in loop 1 as $V_N = -\frac{d}{dt}\int_s B.ds$ where B is the flux density in the plane of loop 2. A sinusoidal source is used to excite the loop. Using the Faraday's law and the definition of mutual inductance the induced noise voltage is obtained., $V_N = j\omega M_{12} I_1$. The mutual inductance between the two loops 1 and 2 of inductances L1 and L2 can be obtained from $M_{12}= K\sqrt{L_1 L_2}$ where K is the coupling co-efficient between the two loops. Here the two loops are identical: $M_{12} = KL$. The constant K can be set to 1 for this configuration based on the approximation that all the flux links between the two loops. However K will vary for different orientation of the loops. The inductance of a loop (placed in air) can be obtained analytically from $L = \frac{\mu_o l}{2\pi}(\ln\frac{4l}{d} - 2.45)$ where l is the perimeter of the loop and d is the diameter of wire [4]. It can also be measured using the impedance analyzer.

A layout with two loops of radius about 12 cm was prepared and assembled concentric and coplanar. From 100 KHz to 1MHz the voltage induced at open end of loop 2 was measured. The inductance of loop 2 was measured using impedance analyzer and found to be 420nH at 1MHz. The current in loop I_1 was not measured but can be obtained analytically from the fact that it is the ratio of voltage excited in loop1 to its impedance. The impedance offered by the loop for a frequency of the excitation can be computed by treating the loop as a series combination of loop inductance (which is the same as that of loop 2 approximately) and resistance R (1K Ohm). A plot of analytical and measured induced voltage is shown in Fig. 9 and a reasonable agreement is found.

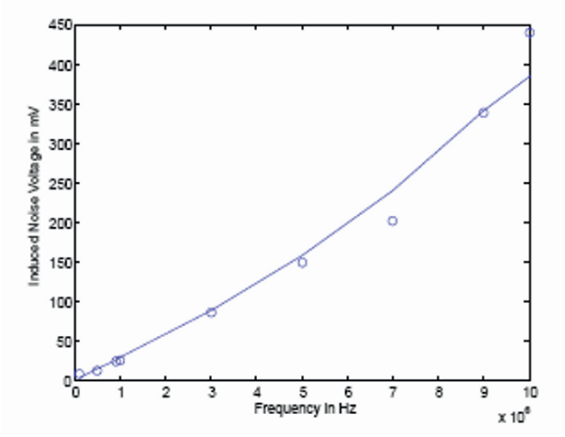


Fig. 9 Induced noise voltage due to inductive coupling (solid lines - computed, dots - measured)

This experiment demonstrates that noise voltages are induced in another loop lying on the same plane as that of another loop due to inductive coupling causing interference. In general in a PCB layout, the voltage induced is due the combined inductive and capacitive coupling. In such complex scenarios, transmission line model needs to be used in predicting crosstalk [5]. But a study of inductive and capacitive coupling

mmeybodi@aut.ac.ir

suggests that neglecting crosstalk can lead to problems in the proper functioning of systems operating at high frequencies.

CONCLUSIONS

This paper has presented a set of experiments for students to understand transmission line parameters, and their effects. The approaches used in these experiments are based on frequency domain techniques. Students of digital system design and/or electromagnetics and communication engineering have been able to understand these essential concepts related to transmission line effects.

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mmeybodi@aut.ac.ir

Web Tool for Teachers: Information Systems on Categorized Teacher Materials and Online Examination

VANESSA CASTILLO-RAMORAN
Department of Math Physics and Computer Science, College of Science and Mathematics
University of the Philippines in Mindanao
Bago Oshiro,Tugbok Dist., Davao City
PHILIPPINES
vcastle_99@yahoo.com

Abstract: **This study developed a web-based organization of a teacher's examination materials. It aimed to answer the pressing need of teachers to efficiently organize exam materials and consequently lighten the load in checking students' answers to examination. This would furthermore give time for teachers to focus on improving and enhancing teaching strategies. The organization of the exam is not limited to long examinations but may cover simple quizzes or final exams. The exam items will be organized per chapter which allows a teacher to specify the coverage (chapters included) during exam creation. To ensure security, simple encryption is applied to login information. The project can assist teachers in giving an online examination where the arrangement of items in a student's exam will be different from another student's exam. The project will automatically check the students' answers freeing the teacher from the burden of checking a load of examination. JSP (Java Server Pages) incorporated with portable java beans were used in developing the project. Because it is web-based there is no need to install the system of the project in all the units that will be used by the teacher in organizing or checking an exam. Furthermore there is no need of installing the system in the computer units that will be used by the students in taking an exam.**

Key-Words: - information systems, on-line examination, paper-based, teacher materials, web

1 Introduction

A university professor or instructor or a secondary high school teacher aims to be effective in teaching. One of the measures for teaching effectiveness is the performance of students in assessment tests.

A Web tool for teachers will:

a) assist teachers in organizing examination materials,
b) allow the students to take examination online in the presence of a proctor,
c) enable the teacher to check examination answers of students online

At present, teachers have their examinations electronically stored in a computer specifically in a word document or its equivalent. If the teacher happens to teach the same subject in the next semesters, he/she inspects the test documents and does improvements. This may look and feel easy to do but in reality it demands time and effort from the teacher. This project lightens the load of the teacher by helping him/her organize examination material in a data bank and by electronically checking the web-based examination.

Why make it Web-based? Sometimes teachers can think of a good exam question when away from the school. It would be a waste not to document these questions. Making exam data bank online enables easy documentation of good questions that just pop from a teacher's mind wherever she/he may be. That is, if exam questions can be posted through the Internet, there is a continuous update of the data bank for exam questions anytime, anywhere.

2 Teachers and students and the traditional paper-based examination

A survey was conducted to college teachers and students and secondary schools teachers and students in some schools in Davao City, Philippines. From the survey conducted, it is evident that there is a common exhausted feeling of teachers after checking examinations. 89.3% of the college teachers and 96.3% of the secondary teachers feel this ways. Please refer to Fig.1.

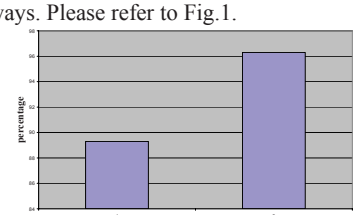


Fig.1: Percentage of teachers who gets exhausted after checking students exam

From the traditional paper based examinations some students sometimes asks paper from classmates. 78% of the college students and 49% of the secondary students do this. This may not be alarming but let us remember that we could have saved trees from these papers that are used.

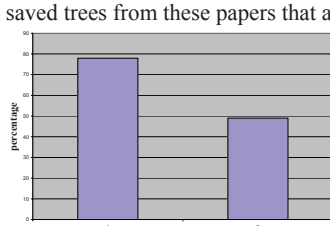


Fig.2: Percentage of students who asks papers from classmates during an exam

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Results of quizzes and assignments are **often** returned by teachers to students. Please refer to Fig.3.

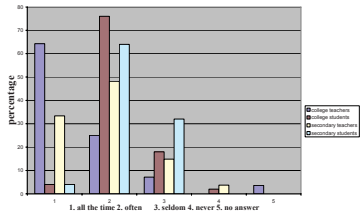


Fig.3: frequency of giving feedback of the result of quizzes and assignment

But our goal is to strive to return all the results of quizzes and assignments **all the time**. Most of the quizzes and assignments are returned within the span of 1-2 weeks. Please refer to Fig.4. Our goal is to return quiz and assignment results faster, say 1 to 2 days.

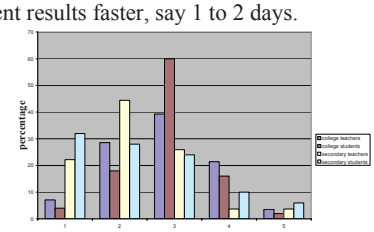


Fig.4: duration before assignments or quizzes are returned

Results of long exams (including but not limited to midterms and finals) are **often** returned by teachers to students. Please refer to Fig.5.

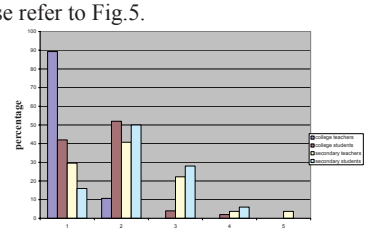


Fig.5: frequency of feedback of the results of long exams

But our goal is to strive to return all the results of long exams **all the time**. Most of the long exams are returned within the span of 1-2 weeks. Please refer to Fig.6. Our goal is to return long exam results faster, say 1 to 2 days.

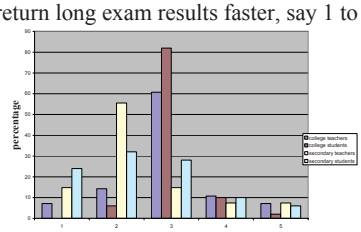


Fig.6: Duration before results of long exams are returned

So how do we remedy the gap from our present examination scheme to achieve our goal of efficiency? An online examination is suggested. It was also checked whether or not the teachers and students are properly equipped to be able to administer examination online.

Teachers and students are already exposed to and are already using computers. Please refer to Fig.7. The secondary teacher percentage on computer use shows the least, but 70% is good enough.

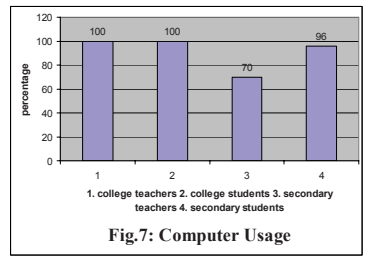


Fig.7: Computer Usage

Teachers and students also show everyday use of computers except for secondary schools teachers. Please refer to Fig.8. They show seldom than once a week frequency of computer use. Maybe it is because they have not fully integrated computers in their everyday task as teachers.

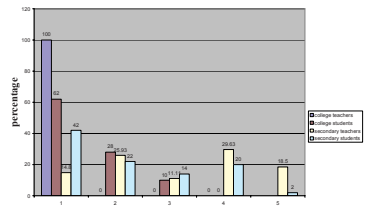


Fig.8: Frequency of computer use

Teachers and students are already exposed to and are already accessing the Internet. Please refer to Fig.9. The secondary teacher percentage on computer use shows the least which is 56%.

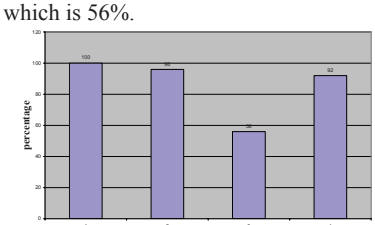


Fig.9: Internet Usage

This may be explained by the lack of Internet connectivity of the school. Frequency of access to Internet varies with teachers and students from college or from secondary schools. Please refer to Fig.10. College teachers show an everyday access to Internet. This may be because they use it to enhance their teaching materials. College students show a once in three days Internet access. This may be explained by their learning augmented by a lot of materials available in the Internet. This could also be attributed to the availability of Internet connection at school. Secondary schools teachers and students show seldom than once a week Internet access. This could be attributed to the lack or insufficient maintenance of connectivity at school.

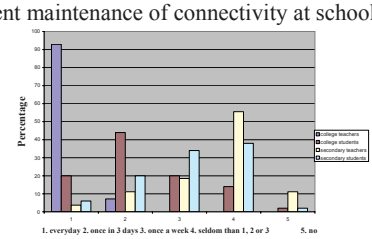


Fig.10: Frequency of Internet Use

Finally the students and teachers are asked whether they

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would be willing to have the examinations online. The purpose is for efficient creation of the exam, fast checking and therefore fast feedback. Majority of the respondents show willingness to have the examination online. Please refer to Fig.11. 93% of the college teachers, 82 % of the college students, 82% of the secondary teachers and 86% of the secondary students are willing to have an examination online.

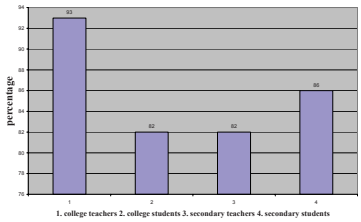


Fig.11: Willingness to have an examination online

A University teacher usually handles 3 to 4 subjects each semester. In each subject the teacher usually gives 3 to 4 long exams to assess what the students have learned. These exam preparations demand time and effort from the teachers. Some teachers handling a certain subject for 3 or more times already still spend time revising and improving their examination materials. This is because most teachers do not like to give the same set of questions in a long exam to students as they might have acquired exam information from students who have previously taken the subject.

3 Web-based material for Teachers

Living in this information age, we have seen rapid and irreversible changes from Information and Communication Technology (ICT). People are having strong expectations of the impact of Internet especially in the educational arena. The Internet has become a vast source of information to augment lecture materials of the teachers. Word processing of computer technology eases exam, lecture and report preparation. The spreadsheets make grade computation faster and lighter. Presentation software aids teachers in the classroom lectures. But still computer technology in tandem with data communications has a lot more to offer for teachers to be more effective and efficient in what they do.

A lot of teaching strategies are available for teachers to use. This is including web-based examination. Roberts (1983) foresees, "future society will be virtually paperless, energy-efficient, dependent upon wide-bandwidth networking, and generally cognizant of global perspective through routine communication across decreasingly relevant borders. " Murden and Brannan reported that there was a substantial time saved grading the web-based tests and assessing student performance. The study conducted by Bocij and Greasly concluded that the use of computers and web based techniques may improve the overall performance of learners as compared to the old methods of assessing learners. Computer-based assessment was bound to improve task focus. The conclusion stems from the fact that if performance increases and the time spent for completing the test decreases, the computer based assessment enhances ability of students to focus on questions and recall relevant information. Because of these findings, a lot of work has been done regarding web-based testing.

Anjaneyulu, Chandrasekar, and Ramani developed VEDA- An On-line generative testing system. Kinnersley, Mayhew, and Scott Hinton designed a web-based computing proficiency examination. Murden, and Brannan reported on using the Internet to facilitate examination of student proficiency. McGough, Mortensen, Johnson, and Fadali developed a web-based testing system with dynamic question generation. Zaharias, Poulymenakou, and Samiotis created web-based testing providing learners with feedback and instructors with a powerful tool for constructing tests.

"To attract and maintain online users, Web site designers must offer interfaces that address specific needs and functions", Palmer commented. This project also caters to the teachers' specific needs. Sometimes a teacher would decide to give 4 long examinations in a given semester. Sometimes they would give three. This is depending on specific chapters covered basing on the syllabus. Utilizing previous exams would be too time-demanding from teachers since the previous exams may not have the same coverage (chapters included) as the current one. This means the content of the examination definitely should differ. If questions in an examination are categorized by chapter, then creating an examination would be easier. Through categorization of examination elements, the usability of the information system is enhanced.

4 The Information Systems on Categorized Teacher Materials and Online Examination as a web tool for teachers

There is an existence of web-based examination in the Internet. However there is no system yet that unifies a categorized exam data bank and web-based administration of examination in one software package.

The systems of the two groups 1) Kinnersley, Mayhew, and Scott Hinton and 2) Murden, and Brannan provide web-based tests which are not categorized by subject matter. There is no question banking mechanism that allows a teacher to organize test questions by chapter. This project (EOL) assists teachers organize their test questions by categories.

Anjaneyulu, Chandrasekar, and Ramani's system, although it can dynamically generate tests is limited by the following feature: an examinee cannot skip questions and later come back to it. This project (EOL) gives the examinee the freedom to review answers by scanning items back and forth.

This project (EOL) allows a teacher to create a data bank of exam items. It will enable teachers to administer a web-based examination to students.

Existing information systems offering online examination updates the database only locally. That is the client side for the teachers to store, edit or delete examination questions is made a stand alone application, not web based. The rationale behind the design of these information systems is to secure their database. But is it

mmeybodi@aut.ac.ir

really secured when the examination is made online? During the examination the web based application fetches question from the database. According to Hughes and Cole, moving data over back-end networks, remote locations, shared recovery centers, and outsourced IT facilities also exposes stored information to technical threats such as eavesdropping, reading the data when it is stored, modifying the data when it is stored, or reading the data off discarded media. An information system for examination materials is more usable if the project is purely web based. Not disregarding the threats of security, simple encryption has been implemented. The access to this project is limited to persons registered by the administrator. The users are the teachers and the students enrolled in the subjects the teacher handles. The account passwords of these users are encrypted.

5 Methodology

The development of EOL followed the Prototyping Model for the System Development Methodology. The system has been gradually tested even if the whole system is not yet complete. The tasks below were performed to complete the project.

A survey was conducted to determine how students and teachers react to the current paper-based examination. The survey further gathers the statistics of computer and Internet usage of students and teachers. The requirements for the online examination were laid down. Triage as cited by Davis in 2003 was heavily used in this requirements phase. According to Davis, Triage is the process of determining which requirements a product should satisfy given the time and resources available. Activities were discussed to perform the triage. One of these activities which the researcher practices is "Maintaining a list of the requirements". The researcher considered the needs of the three main users: teachers, students and teachers. Triage also points out to 1. "Record necessity interdependencies", 2. "Annotate requirements by effort", and 3. "Annotate requirements by relative importance. Although there are still other activities enumerated by triage the 4 activities mentioned above were the activities heavily practiced by the researcher.

The classes for EOL (Examination On Line) Project were designed. These classes produced the beans (java objects) that are used in the Web based information systems project using JSP (java server pages). All the database access are encapsulated in the java beans, hence this is the first level of security implementation of the project.

6 Technologies

The project used the Java Technology to develop the beans. These beans are used to communicate with the database. These beans are then accessed by the Java Server Pages (JSP). The JSP files serve as input/output components. That is the users do the operations they desire by putting input to JSP files. The beans do the operations. And then the system uses the JSP files again to deliver results of the operations to the users. The project used MySql for database management.

This web based system of this project "Information System on Categorized Teacher Materials and Online Examination" is called EOL (Examination OnLine).

7 Architecture of the Information Systems for Categorized Teacher Materials and Online Examination

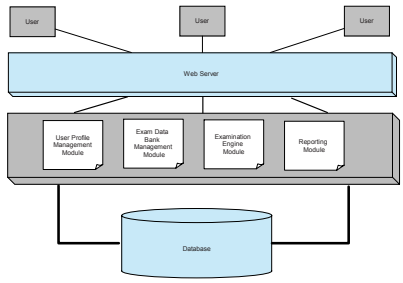


Fig.12: Web-based Teacher Assistant System Architecture

7.1. Web-based Teacher Assistant Modules

EOL is composed of four modules:

- User Profile Management Module
- Exam Data Bank Management Module
- Examination Engine Module
- Reporting Module

7.1.1 User Profile Management Module

This is the module that organizes profiles of teachers and students. There is an administrator that can add, edit, delete or retrieve profiles of teachers and students. This module manages the roles of teachers and students.

7.1.1.1 The teacher. The teacher can organize the subjects. The system allows a teacher to divide a subject into chapters. After the subject has been organized, the teacher can now construct question items. A teacher can dynamically create a set of test questions and administer to a specified set of students.

The teacher can manipulate the access status of students in an examination. The teacher can open or close the exam to students. When it is open the student can take the exam. When the access is closed the student cannot take the exam. This is to make sure that only the students that have proctors can take the exam. A teacher may also be able to view the test results of the students.

7.1.1.2 The student. A student can take a test. A student may view his/her own test result. Initially their password is set by the Administrator. But they can be changed anytime they want.

7.1.2 Exam Data Bank Management Module

This is the module that enables a teacher to add question items to the exam data bank. It is the module that allows a teacher to store, delete or modify questions in the database. Before storing the questions items to the database, it must be specified which chapter it belongs. The system supports

mmeybodi@aut.ac.ir

the following type of questions:

1. Multiple choice
2. Fill in the blanks
3. Matching Type
4. True or False
5. Modified True or False
6. Essay
7. Problem Solving

The teacher specifies the level of difficulty of a question during construction. The level of difficulty may be easy, average, or difficult.

During test construction, that is, selecting a set of test questions, the teacher specifies the coverage: the chapters included. The teacher also needs to specify distribution of examination: for example 25% easy, 50% average and 25% difficult. After a test material has been constructed it will be ready for students to take. For make up exams, the teacher has an option of creating a new set of questions. The teacher must specify the same coverage and difficulty distribution to assure fairness.

7.1.3 Examination Engine Module

This is the module that gives test to students. The test contains the same set of questions but differently randomized for every student. That is, a question item might be question number 1 to one student, question number 8 to another student or question number 10 to still another student.

7.1.4 Reporting Module

This module enables student to view test results. The teacher may also view the result of the test as a whole.

8 Results and Discussion

EOL: The Information Systems on Categorized Teacher Materials and Online Examination

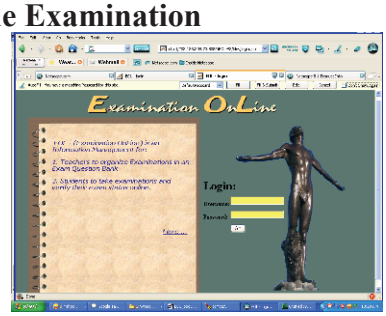


Fig.13: Login page for EOL

EOL system has been developed as an Information System on Categorized Teacher Materials and Online Examination. The users catered were the teachers, students and students. The bulk of the system assists the teachers in his/her exam preparations. The teacher is the one who organizes her subjects. In every subject, chapters are categorized and in every chapter questions are divided. After the exam bank has been created, an examination can be prepared by the teacher. This does not limit the teacher from updating the exam data bank anytime, anywhere. Fig. 14 shows the main page for a teacher. The operations she/he can do are depicted in this page.

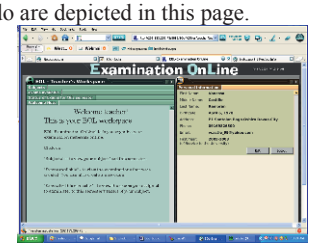


Fig.14: EOL main page for teacher

After the examination is created, the teacher can adjust the students' access to the exam. This is the teacher's discretion on who can take the exam or not. The teacher can also randomize the exam so that students' questionnaire are differently randomized from one another. After an examination is given, the teacher can let the system automatically check the multiple choice questions, matching type questions and the true or false questions. The teacher can check the other examination types: modified true or false, essay and problem solving online. The teacher has the option of checking filling the blanks questions manually (if he/she allows incorrect spelling) or automatically through EOL. The teacher can view the students' answers and give the corresponding score online. After all the exam questions are checked, the teacher can use the system to compute the students' total score. After the checking and computations, exam results can be viewed by the teacher.

Fig. 15 below shows the main page for the Administrator. The operations that the Administrator can do are depicted in this page.

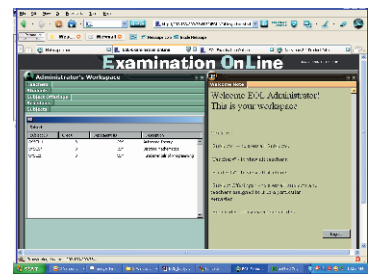


Fig. 15: EOL main page for Administrator

The administrator basically manages the accounts of the students and the teachers. Only the administrator can register a teacher or a student.

Fig.16 shows the main page for the students. The operations that the students can do are depicted in this page.

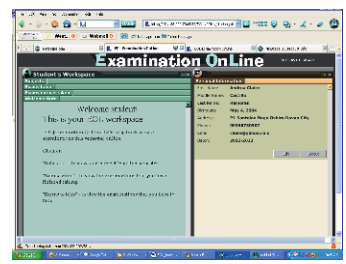


Fig. 16: EOL main page for Student

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The student uses EOL to take an examination online. This is if she has been given access by the teacher. After an exam is taken and after it has been checked by the teacher, the student can view his/here exam results online.

At the testing and maintenance phase, an exam was created using the system with the following details in Fig. 17.

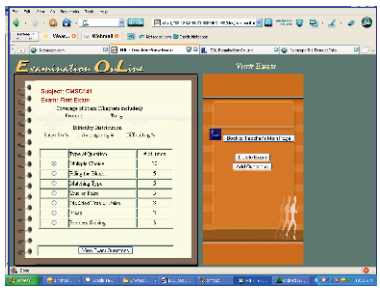


Fig. 17: Exam details for an exam created using EOL

9 Conclusion

For ease and efficiency, teachers may use EOL to organize their examination materials. Consequently the students may take the exam online allowing the paperless examination. This will bring about fast feedback of the students' examination results. Fast feedback is made possible by the automatic checking of multiple choice, filling the blanks, matching type and true or false questions. The other types modified true or false, essay and problem solving may be checked by the teacher online. The teacher gives the corresponding score to every student's answer. Computation of the total score is done by EOL. EOL enables the teacher to construct and maintain examination bank anytime and anywhere. In EOL all users' account are protected by the simple encryption implemented by the researcher.

10 Recommendation

The objectives of easing the workload of the teacher and faster exam result feedback to students have been achieved by EOL. The examination data bank can be constructed by the teachers and examination materials can be automatically generated. On top of the features of EOL, there is still a mechanism that would further help teachers in their tasks. This is inputting questions by bulk. Questions may be collected in a file, maybe a text file or a spreadsheet file. These collected questions may then be saved in the database through parsing the file.

This system also uses the explorers used by the user. This system implements dynamic web pages and needs the data from the previous page. If the user clicks the "back" option of the browser, the data may not be properly captured and EOL may not function properly. A research may be done to over ride the "back" functions of a browser.

In this design of this information system, a subject is owned and manipulated by one teacher only. There are universities where one subject is taught by two or more teachers in different sections but in the same semester. The system may be upgraded so that two or more teachers can manipulate and update one subject.

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mmeybodi@aut.ac.ir

Teaching Operating Systems Using Visualization: A Comparative Study

Xiaohong Yuan, Barbara Pioro, Ricky Archer, Yaohang Li
Dept. of Computer Science
North Carolina A&T State University
1601 East Market St., Greensboro, NC 27411 USA

***Abstract* - Research has shown that, for a visualization technology to be educationally effective, it has to engage learners in an active learning activity. In this paper, the effectiveness of visualization tools used in Operating Systems courses is studied. We compared the ways the MLFQ and CAMERA visualization tools were used in Operating Systems classes in different semesters, as well as student performance in those classes. The learner engagement with visual technology in this study at the "viewing", "responding", and "changing" levels are compared. Our results show that learning improves as the level of student engagement with visualization technology increases.**

I. INTRODUCTION

Visualization technology has been used to graphically illustrate various concepts in computer science. There is a wide spread belief among computer science educators that visualization technology positively impacts learning [1]. However, research has shown that, for a visualization technology to be educational effective, it has to engage learners in an active learning activity [1, 2].

Visualization tools have been used in the Operating Systems classes at this university for several semesters. In this study, we compared the ways the visualization tools were used in teaching Operating Systems classes, and student performance. The intention of this study is to gain insight in how visualization tools can be used to benefit student learning.

In the report of the working group on "Improving the Educational Impact of Algorithm Visualization" [1] six different forms of learner engagement with visualization technology are defined. They are:

1) No viewing. It refers to instruction without any form of accompanying visualization.
2) Viewing. It is the core form of engagement since all other forms of engagement with visualization technology fundamentally entail some kind of viewing. Viewing by itself is a passive form of engagement. It does not entail active involvement aside from controlling a visualization's execution and changing views.
3) Responding. It involves answering questions concerning the visualization presented by the system.
4) Changing. It involves modifying the visualization, for example, changing the input of the algorithm under study.
5) Constructing. Learners construct their own visualizations of the concept under study.
6) Presenting. Learners present a visualization to an audience for feedback or discussion.

The study conducted in algorithm visualization [2] shows that learning improves as the level of student engagement in algorithm visualization increases. Improvement occurred between "not viewing" and "viewing" and between "viewing" and "responding" levels. In this study, the learner engagement with visual technology at the "responding", "changing" and "viewing" levels are compared. Our results show that learning at the "responding" level is better than at the "viewing" level, and learning at the "changing" level is better than at the "responding" level.

The remainder of the paper is structured as follows. Section 2 introduces the visualization tools used in the Operating Systems classes. Section 3 describes the procedure used in the study. Section 4 discusses our results and section 5 gives the conclusion.

II. MATERIALS

In this section, the two visualization tools used in our Operating Systems courses are described. These tools are: MLFQ and CAMERA.

A. MLFQ Tool

CPU scheduling is one of the important materials covered in an Operating Systems course at the undergraduate level. MLFQ [3] is a software package that simulates the multilevel feedback queue scheduling algorithm for a single CPU. The package is written in Java. It simulates the MLFQ algorithm by using four queues and two different kinds of jobs: regular and batch. Fig. 1 shows a snapshot of the MLFQ tool. Users can choose among four available input data files, or enter their own input data. The user can choose a step-by-step approach to understand the details of the algorithm, by repeatedly clicking on "Trace", or the user can click on "Run" to have the tool go through the steps and display the CPU schedule for the input data. At the end of the simulation, a "Statistics Result" windows pops up and displays the response time, waiting time, process turnaround times and overall turnaround times and the CPU utilization for this simulation.

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 576–580.
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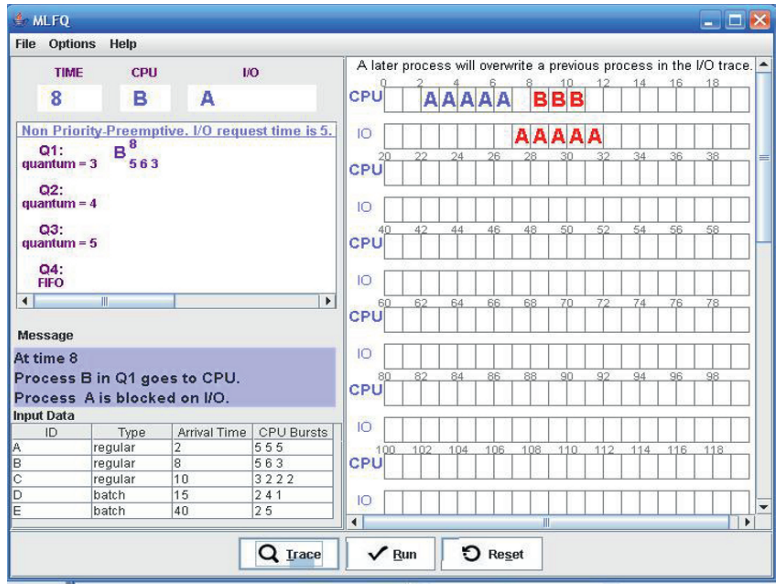


Fig. 1. Snapshot of the MLFQ tool

B. CAMERA Tool

CAMERA (Cache and Memory Resource Allocation) [4], implemented in Java swing, is a collection of workbenches for cache mapping schemes and virtual memory. It provides users with interactive tutorials and simulations to help them better understand memory management concepts. The virtual memory workbench in CAMERA was used in the Operating Systems classes. Fig. 2 shows a snapshot of the CAMERA virtual memory workbench. The interface contains the address reference string, the virtual and physical address bits, the TLB, the page table, the physical and virtual memory space for each process, and the statistics on TLB hits and misses and page hits and faults. The simulation demonstrates how CPU extracts the virtual page number from a virtual address and then uses it to find a matching entry in the TLB or the page table. If a match is found in either, the virtual address is translated into physical address and the data is retrieved from the physical page frame. If a match is not found, the faulting page will be placed into the physical memory, the page table and TLB are updated, and the data is accessed from physical memory.

III. PROCEDURE

This section describes how the MLFQ and the CAMERA Tools are used in the Operating Systems course for three semesters.

A. *Using the MLFQ Tool*

In Fall 2004, the MLFQ tool was briefly introduced in the class. The students were then asked to explore the tool, and homework assignment was given to the students. The homework assignment asked the students to: (1) Provide a user's manual for the MLFQ; (2) Make up their own input data, and trace the simulation using the input data. For each step, explain what occurs and why; (3) Calculate response time, turn around time and waiting time, and compare their result with the result given by the tool; (4) Evaluate the tool by describing: what they like about this tool; what they dislike about this tool; if they think working on the tool helps them to learn Operating Systems concepts, and if they have suggestions on how to improve the tool. To assess the student performance, a final exam problem was given to the students to simulate the MLFQ algorithm, with input data similar to that used in the tool. According to the six different forms of learner engagement with visualization technology, this assignment engages the students at the "responding" level.

In Fall 2005 and Spring 2006, the students were given the above assignment, and an extra exercise problem. The students were asked to simulate the MLFQ manually with only two queues, the second queue using the Round Robin algorithm. The students were not able to trace the tool to get the answer, since the tool includes four queues, and the fourth queue uses the FIFO algorithm. This added exercise problem engages the learner at the "changing" level, since it changed the number of queues, and the algorithm used with a queue in the MLFQ algorithm. A final exam problem was also given to assess student performance on learning the MLFQ algorithm.

mmeybodi@aut.ac.ir

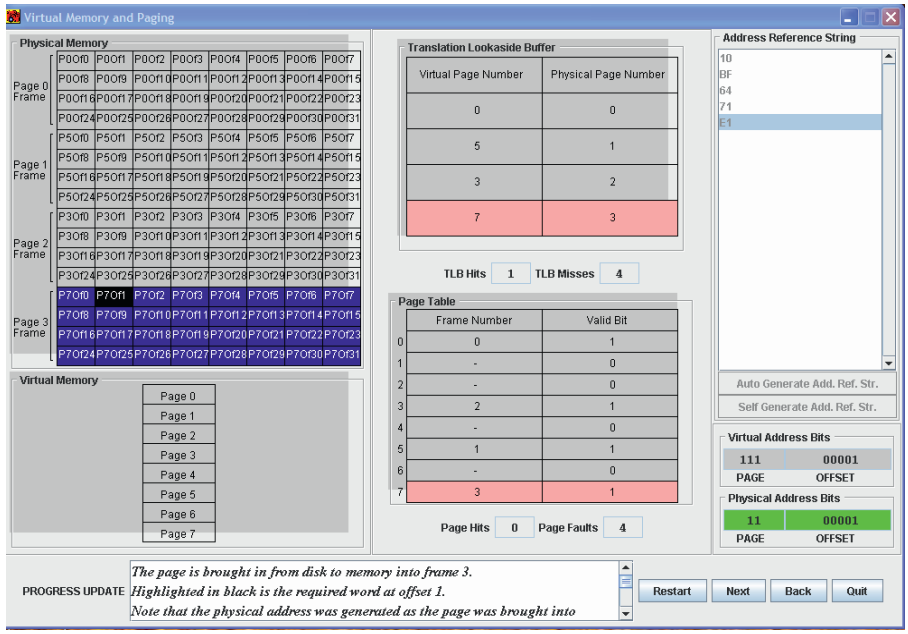


Fig. 2. Snapshot of the CAMERA Virtual Memory workbench

B. *Using the CAMERA Tool*

In Fall 2004, the CAMERA tool was introduced to the students. The students were given an assignment to explore the tool, and evaluate the tool. The students were asked to explain: (1) What concepts CAMERA Virtual Memory and Paging simulation tool demonstrate; (2) The concepts that are difficult to understand which the tool helps them to understand; (3) Difficulties they find in learning this tool; (4) What they like and dislike about the tool; and (5) Any suggestions on improving this tool. This assignment engages the students at the "viewing" level.

In Fall 2005 and Spring 2006, the students were given the above assignment, and an extra exercise problem. The students were asked to change the input string, and explain: (1) Given a virtual address, if this address would cause a TLB hit or TLB miss; (2) If this address would cause a page fault; (3) The physical address for this virtual address. This assignment engages the students at the "responding" level. In all three semesters, a final exam problem was given to assess students' learning of virtual memory and paging concepts.

IV. Results and Discussion

We compared the scores of the MLFQ and the CAMERA problems in the final exams in the three semesters. The same instructor taught the Operating Systems course during all the three semesters, and graded the final exam problems consistently. Since final exams are never given back to the students, the students do not have access to previous years' final exam. The MLFQ and CAMERA problems in the final exams are very similar in the three semesters. We also compared the students' learning style and calculated the correlations among a student's learning style, his test scores, and the student's GPA. Our results are discussed below.

A. *Final Scores of the MLFQ Problem*

The average scores of the MLFQ problem in the final exams in the three semesters are listed in Table I.

TABLE I
AVERAGE SCORES OF THE MLFQ PROBLEM

Semester	Number of students	Average MLFQ score
Fall 2004	31	31.38
Fall 2005	11	43.36
Spring 2006	31	57.32

Non-parametric Kruskal-Wallis and Mann-Whitney Tests were conducted on the scores of the MLFQ problem. A 5% significance level was used. Mann-Whitney Test results show that the difference between Fall 2004 and Fall 2005, and the difference between Fall 2005 and Spring 2006 are not significantly different ($p = 0.314$ and 0.126 respectively). Yet the difference between Fall 2004 and Spring 2006 is *highly significant* ($p = 0.0001$). This leans towards supporting the conclusion that improvement occurred between student engagement in visualization at the "changing" level and the "responding" level.

mmeybodi@aut.ac.ir

B. *Final Scores of the CAMERA Problem*

The average scores of the CAMERA problem in the three semesters are listed in Table II.

TABLE II
AVERAGE SCORES OF THE CAMERA PROBLEM

Semester	Number of students	Average CAMERA score
Fall 2004	31	35.75
Fall 2005	11	61.36
Spring 2006	31	72.58

Non-parametric Kruskal-Wallis and Mann-Whitney Tests were conducted on the scores of the CAMERA problem. A 5% significance level was used. Mann-Whitney Test results show that the difference between Fall 2004 and Fall 2005, and the difference between Fall 2004 and Spring 2006 are significant ($p = 0.005$ and 0.00002 respectively). The test also shows that the difference between Fall 2005 and Spring 2006 is not significant ($p = 0.137$). This supports the conclusion that improvement occurred between engagement in visualization at the "responding" level and the "viewing" level.

C. *Learning Style*

In each of the semesters, the students completed a self-rating of preferred learning style, using the questions given in [2]. Kruskal-Wallis tests were used to compare the learning styles of the students of the three semesters. The survey results show that there is no significant difference among the learning styles of the students of the three semesters ($p = 0.55$). Overall, our survey results show more students prefer visual learning style than non-visual learning style.

D. *Correlation of Learning Style with Test Score and GPA*

Our data show that there is weak correlation between the learning style of a student and the test scores of the MLFQ problem and the CAMERA problem ($r^2 = 0.14$ and 0.0002 respectively). Similar to the result in [2], our data do not support the suggestion that visualizations are more helpful to visual learners than non-visual learners [5]. Also the correlation between the learning style of a student and the student's GPA is very weak ($r^2 = 0.0009$). There is weak correlation between the student's GPA and the test scores ($r^2 < 0.2$). There is no significant difference between the GPAs of the students in the three semesters ($p = 0.72$). This shows that the students during different semesters have similar academic abilities.

E. *Student Questionnaire Results*

The students were asked to evaluate the tools in terms of features they liked and disliked, and were asked to give suggestions to improve the tool. The evaluation results are summarized in Table III and Table IV.

TABLE III
MLFQ EVALUATION RESULT

Features Liked	1. The visual representation of the queues 2. It is easy to use 3. It is simple
Features Disliked	1. The tool freezes at times 2. The user has to re-enter data if a mistake is made when entering input data 3. The tool has minor bugs 4. The user could not change scheduling algorithms
Suggestions	1. Provide the ability to review previous steps 2. Show the equations used for calculating the statistics 3. Provide better explanation of the topics demonstrated by the tool
The number of students being evaluated: 79 The number of students who thought the tool was useful: 73 (92.4%) The number of students who disliked the tool: 6 (7.6%)	

TABLE IV
CAMERA EVALUATION RESULT

Features Liked	1. The graphical representation of the tool 2. Thorough explanation of the tool 3. The User's manual 4. The tool is easy to use
Features Disliked	1. The students had difficulties running the program on some computers 2. The tool is confusing sometimes
Suggestions	1. Change the color of the background to make it more inviting
The number of students being evaluated: 73 The number of students who thought the tool was useful: 70 (95.9%) The number of students who disliked the tool: 3 (4.1%)	

mmeybodi@aut.ac.ir

Overall more than 90% of the students considered both tools useful. According to [6], some of the impediments to the adoption of visualization tools by instructors for use in teaching and learning computer science concepts are "the time it takes to learn the new tool" and "the time it takes to adapt visualizations to teaching approach and/or course content". In this study, the students liked that the tools are easy to use, and the instructor of the Operating Systems courses found it easy to adapt the above tools to course content. High quality support materials such as user manuals, novice-friendly and visually appealing GUIs are important to the users of the visualization tools.

V. Conclusion

MLFQ and CAMERA are visualization tools used in an Operating System course at this university for several semesters. This paper compares the ways these visualization tools were used and the resulting student performance. Our results show that learning improves as the level of student engagement with visualization increases. Our data show improvement occurred between the "viewing" and the "responding" levels, and between the "responding" and the "changing" levels. Our data do not support the suggestion that visualizations are more helpful to visual learners than non-visual learners.

The working group on "Improving the Educational Impact of Algorithm Visualization" has suggested metrics for assessing the learning outcomes grounded in Bloom's taxonomy of understanding, and has presented a framework for experimental studies of visualization effectiveness based on the taxonomies of engagement and the effectiveness metrics [6]. Our future work will be conducting studies measuring visualization effectiveness in teaching Operating System courses using this framework.

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mmeybodi@aut.ac.ir

Leave Management Software for University Personnel

[1] Xiaoquan GAO *, [2] Yuheng WANG

[1] Département Informatique, Université Paris II
92, rue d'assas, 75270 Paris, FRANCE
e-mail: gao@u-paris2.fr or xiao.gao@free.fr

[2] Institut de Minéralogie et de Physique des Milieux Condensées, Université Paris VI
140, rue de Lourmel, 75015 Paris, FRANCE
e-mail: yuheng.wang@impmc.jussieu.fr

*: Corresponding author

***Abstract*- An on-line system of leave management for personnel has been required by agents of Human Resource service in many universities. A software system of this kind, developed by the IT service department of the University of Paris II in 2005, has been operational since 2006. With total satisfaction to the Human Resource service, this software answers precisely the demand of the university.**

The primary objective of this software system is to replace the "paper form" by an automatic e-mail exchange between the agent who makes the leave demand and the superior department head of this agent who validates, or not, the demand, motivated in case of a refusal. Each agent can consult the situation of his demand at anytime and each superior (like the president, the general secretary and the head of every department) can consult the situation for all the agent of his department at anytime.

This system includes several algorithms perfectly adapted to the complicities of the leave management, for which it takes the following parameters into account: the agent status: contractual and partial time; the demand motive and the sort of demand: demand for the future and regularization demand, motherhood leave, bonus leave, long malady; the particular cases: Saturday working agents, the service structure and multiple university sites. The database is MySQL relative. The personalized calendars are provided for both the agents' side and the superiors' side. The leave tables for every agent use pixels-dates scanning. All these are the original features of the presented software system presented here.

I. SPECIFICATION

This system is designed for both intranet and internet, with the relational base MySQL 4. It is programmed in Servlet Java for the server part, on an application server Jonas (Tomcat 4), and in JavaScript for client part. The program package Javamail [1] is used for e-mail exchange among agents, superiors and Human Resource.

The system comprises three independent parts: (I) leave requests by agents, (II) validation by his superior department head and (III) leave administration by the human resource service.

The functions for agents are the following: leave request (one day or half a day, graphic and dynamic calendar); consulting their situation at any moment (graphic table); consulting the request lists in progress and canceling them, demanding regularization and permanence. The functions for

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 581–585.
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superiors are the following: validation (or not) of the leave request, with a motive in case of refusal; overall view of service absences; canceling validated requests; regularization and particular cases like Saturday work, creation and modification of sub-services. The functions for the Human Resource are the following: creation or modification of the name of university sites, services, the superiors department head, the permanent and contractual agents; parameter defining of the university calendar: annual credit (full or partial time), legal holidays, spring, summer and winter holidays; initial parameter defining of personal balance, consulting the leave by agent and by service; overall view of service absences; canceling the leave validated by his superior department head; creation or modification of leaves by agent; transfer of agents between university services.

Until now, the database of the University Paris II comprises 14 university sites, 76 services and 364 agents. The leaves management is used via intranet from September 2006.

II. Structure of Leave Database

The leave database is composed of three participants: the Administrator & Human Resource, the Superior department head and the Agent, three assembly parts and 18 application modules (Fig. 1).

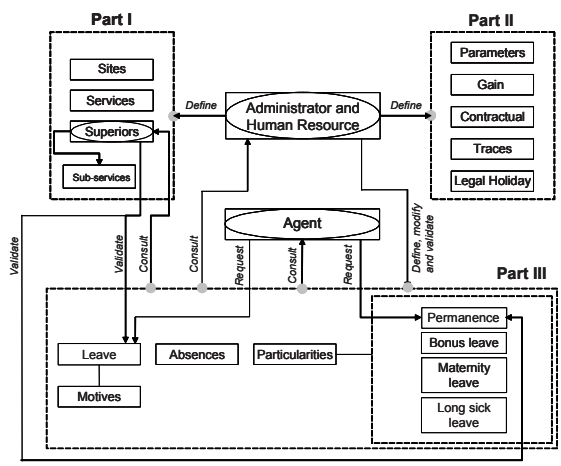


Fig. 1. Structure of the leave management database. Each rectangle in solid line represents a table in the base; each eclipse represents a real human part interacting with the system; each rectangle in dashed line represent an assembly of tables. The solid lines with arrow indicate the interactions between the human parts and the tables of the database.

The Administrator & Human Resource is the super administrator of the whole service system. It manages the Part I (Sites, Services and Superiors), the Part II (Parameters, Balance, Contractual, Traces and Legal holidays) and the Part III (Leaves, Absences, Particularities, Permanence, Bonus (extra leave), Maternity leave and Long sick leave). The Superior department head and the Agent have the same creation and modification rights. The Superior department head can also create or modify its sub-services. The Part III can be consulted at any moment by the agents, the superior department head.

The leaves can be requested by agents, and they can then be validated by their superior department head directly, or by the human resources service indirectly in case of the absence of the superiors department head. The data in the Part III are routinely updated.

The tables in the Part II and the Part III are linked in real time. For example, the field “balance” of the present university year in the table “Traces” in the Part II is modified immediately once the fields “beginning date” and “end date” are changed by the superiors department head or the human resource service, who can modify the leave request made by agents.

The leave not taken by an agent is always equal to the leave balance of the precedent year (Fig. 2).

Reliquat 2005-2006	20,0
Droits 2006-2007	52,0
Total des droits	72,0
Consommations	11.0
Fermeture universitaire	36,0
Solde :	25,0

Reliquat 2006-2007	25,0
Droits 2007-2008	52,0
Total des droits	77,0
Consommations	4.5
Fermeture universitaire	36,0
Solde :	36,5

Fig. 2. The leave balance of 2005-2006 is equal to the remainder leave left of 2006-2007.

mmeybodi@aut.ac.ir

This correlativity is applied to the fields “annual credit” and “university closure” of the table “Traces” and all the fields in the tables “Absences”, “Permanence”, “Bonus” “Maternity leave” and “Long sick leave”. This rigorous correlativity assures the automatic correction of the read-out of the digits at the high-right in the leave table (Fig. 3 & Fig. 4) and the leave transference between two consecutive years.

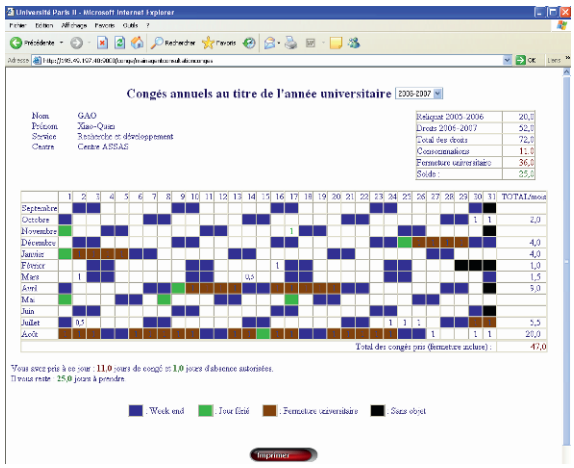


Fig. 3. The leave table for the university year 2006 - 2007.

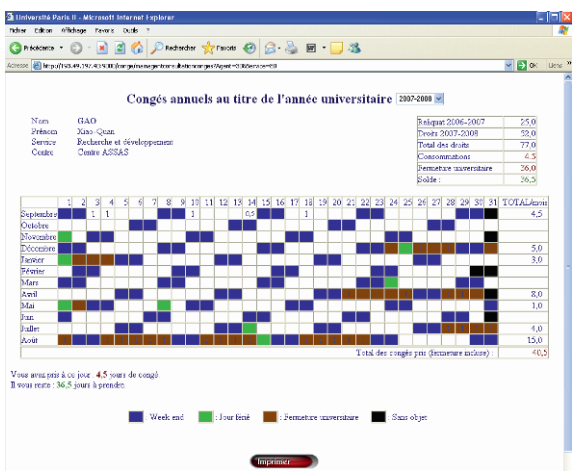


Fig. 4. The leave table for the university year 2007 - 2008.

III. Personalized Calendar

The architecture deployed is the co-operation between the server part, developed in J2EE, servlet Java, and the client side, developed in JavaSript. The data of leave of the personnel are sent to the client (agent) by the server. Using the technique of innerHTML in getElementById in the language Javascript [2], we locally build at the client side a chain of characters which contains the data of the agent concerning the pre-execution of the personalized calendar.

In the monthly calendar of leave request for the agent, there is a common part in red which is deactivated (Fig. 5). These days correspond to three periods of university closure, legal holidays and weekends. Furthermore, the calendar takes into account the personal situation of each agent, such as that the posterior leave (in the course of validation or to be validated) must also be deactivated. And the former leave must also be deactivated for the regularization (Fig. 5, days barred in green). In case of request for permanence, only the periods of university closing are opened to be filled by agents.

The inhibition of the dates is affined to half-day. For example, in the case that the morning of September 14, 2007 in the calendar in Fig. 5 is already an objective a certain leave request, when the agent request the same date, the option button “afternoon” is automatically proposed in the field of beginning of leave request, and the “morning” and “full day” are deactivated (Fig. 6).

The arrow in the calendar can be displayed to the right in

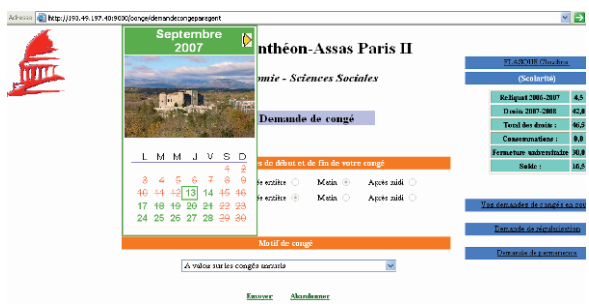


Fig. 5. The personalized calendar.

mmeybodi@aut.ac.ir

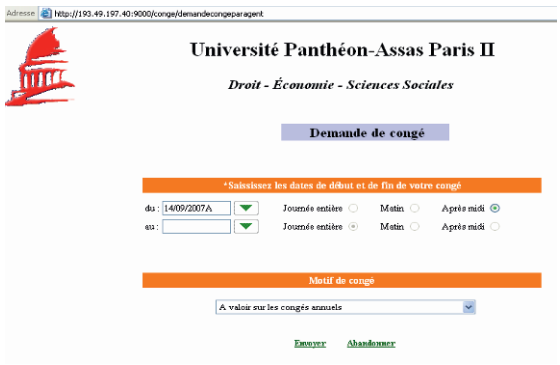


Fig. 6. The result of the date choice: September 14, 2007.

case of leave request or to the left in case of regularization demand (Fig. 7).

IV Pixels-Dates Scanning in the Leave Table

When an agent save his leave request, the first click in its calendar gives the date of the leave beginning and the second gives the date of the leave end. Between these two dates, the possible university closure, legal holidays, weekends and days of authorized absences is put in gray, after scanning the tables. This dates scanning is like to the pixels scanning in the image processing [3 & 4].

A transferring factor of leave is defined as "α", whose initial value is equal to 0, and equal to 1 when the scanning of the dates meets a start date of leave. It maintains this value until the scanning of the dates meets the end of date of this leave, when its value returns to zero. So on until the end of the university year. The definition is the same for three periods of university closure, defined as "β", permanence and agent absences defined as "γ".

Three transferring factors, α, β and γ, the value λ for legal holidays and the value μ describing the weekends (0 and 6) and defined by the formula of Zeller [5] have varied importance in the process of pixel-dates scanning, $\mu > \lambda > \beta > \gamma > \alpha$, which gives the favorite result for the leave table. If this inequality order is modified, the priorities of manifestation of these elements will be changed and this change can be seen on the table.

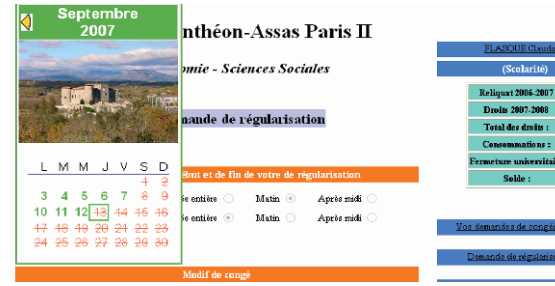


Fig. 7. The arrow to the left indicates the demand of regularization.

Therefore, the leave table is the image of an application of the three transfer factors (α, β and γ), λ and μ. This method has suitable interests in the case of several registrations of leave, which often arrives in the real-time routine update of software.

V Conclusion

The management software of leave has been used at the University Paris II for one year and a half, and it was much appreciated by Human Resources. It is presently tested by other Universities (Université de la Rochelle ...). The performances of the software is based on original methods of data processing: sweeping "pixel-date", which is a transposition of the time data in an image plan. This transposition makes it possible to use powerful tools for image processing. The personalized calendar could be extended to Artificial Intelligence, which will manage not only the dates of the events, but also their nature (vacation, course, subjects of research, meetings,…).

Acknowledgment

The authors want to thank Damien SCHOEVAERT, Anne Marie COURTOT, Daniel PELTIER and John WISDOM for

mmeybodi@aut.ac.ir

their helpful language improvement for this article. This work is supported by the Human Resource department of the University Paris II.

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mmeybodi@aut.ac.ir

On-line Virtual Real-Time E-Collaboration: An Innovative Case Study on Engineering Research Teleconferencing Management

Tarek Sobh and Sarosh Patel
Department of Computer Science & Engineering
University of Bridgeport
{sobh , saroshp}@bridgeport.edu

Abstract: The Internet has greatly extended the boundaries of human interaction. Virtual on-line interactions and collaborations via the World Wide Web have become very common place in recent times. It was only a matter of time before these technologies were applied to knowledge sharing and management. In this paper we discuss the CISSE International Online E-Conference, the World's first and only high caliber scientific conference to be completely conducted and managed online. CISSE is an innovative approach of conducting and managing an engineering research conference via the internet. CISSE provides a very convenient, time saving and user friendly platform for global scientific and research interactions.

Introduction

International scientific conferences have played an important role in the history of scientific evolution. They serve not only as centers for the exchange and sharing of ideas and knowledge (which would otherwise remain localized), but also as a means of verifying and documenting scientific research. They have been serving as platforms where many theories were challenged, disqualified and new ones proposed, giving direction for future research.

Many studies and surveys have recently pointed out the increasing number of scientific publications in non American countries, especially China, India and central Europe. NSF (National Science Foundation) recently released reports about the decline in the American share of published articles in science and engineering worldwide — not exactly surprising in light of the growing influence of scientists from Asia and Europe [1]. But such an increase fails to be seen in terms of foreign participation at international conferences conducted in the US.

Factors Influencing Global Participation

Even though participation in technical conferences is only on the basis of merit of the research and not limited by geography or nationality, very model or the method in which these conferences are conducted discourages international participation. Secondary factors such as current socio-political constraints, issue of Visas, time out of office, costs associated with international travel and lodging and suitability to one's work schedule are important deciding factors that often influence and limit the participation of leading researchers, scientists and professionals especially from overseas.

In most cases, academic institutions in developing nations fail to sponsor (or cannot afford) inherit high costs associated with participating in international conferences due to high currency exchange rates. This leads to indirect seclusion of the scientific community from the third world where a major part of leading research is being conducted. The marked increase in scientific publication in local national and international conferences conducted within respective countries bares testimony to this fact.

Participants from developing countries require a valid Visa to be able to attend conferences held within the US. In the existent socio-political scenario Visas have become hard to obtain and not to mention the fact that the participants need to apply for appointment at local embassies/consulates few months in advance.

Such unforeseen factors make a rather simple endeavor of participating in an international conference into loads of paper work often involving

M. Iskander (ed.), *Innovative Techniques in Instruction Technology, E-learning, E-assessment, and Education,* 586–591.
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mmeybodi@aut.ac.ir

the bureaucracy. As a result most of the international conferences today are not representative of the global cutting-edge research being conducted internationally. Limiting their scope to the geographies at which they are being held they have lost the meaning of the term 'international'.

To counter this problem many International conferences such have adopted an approach of annually holding conferences in different continents/countries. Even though, this can be considered to be an improvement over the earlier model, it is essentially equivalent to moving the same problem across different geographies.

With the advent of the internet the world has turned into a *'global village'* and geographical distances have dramatically become non-existent enabling real-time human interactions across continents simple and affordable. Managing and synchronizing efforts scattered all over the globe using VoIP (Voice over IP) and other web-conferencing tools has become a reality. The CISSE international conference applies these technologies to the problem at hand to bridge the divide.

The CISSE International E-Conference

The CISSE (Computer, Information, and Systems Sciences, and Engineering) International Online E-Conference, the World's first and only high caliber scientific conference to be completely conducted and managed online. The CISSE international joint conferences is an attempt to technologically overcome these unseen barriers and provide a truly global platform for leading researchers, scientists and engineers to participate, present and discuss their ideas. CISSE provides a virtual forum for presentation and discussion of the state-of the-art research on computers, information and systems sciences and engineering.

CISSE 2007 was the third conference in the CISSE series of conferences was yet another success. CISSE 2007 received a total of 716 paper submissions were received and the final CISSE 2007 program included 406 accepted papers, from more than 70 countries. CISSE 2006 received 690 research paper submissions, which was more than double the number of submissions for CISSE 2005, and the final program for CISSE 2006 included 370 accepted papers.

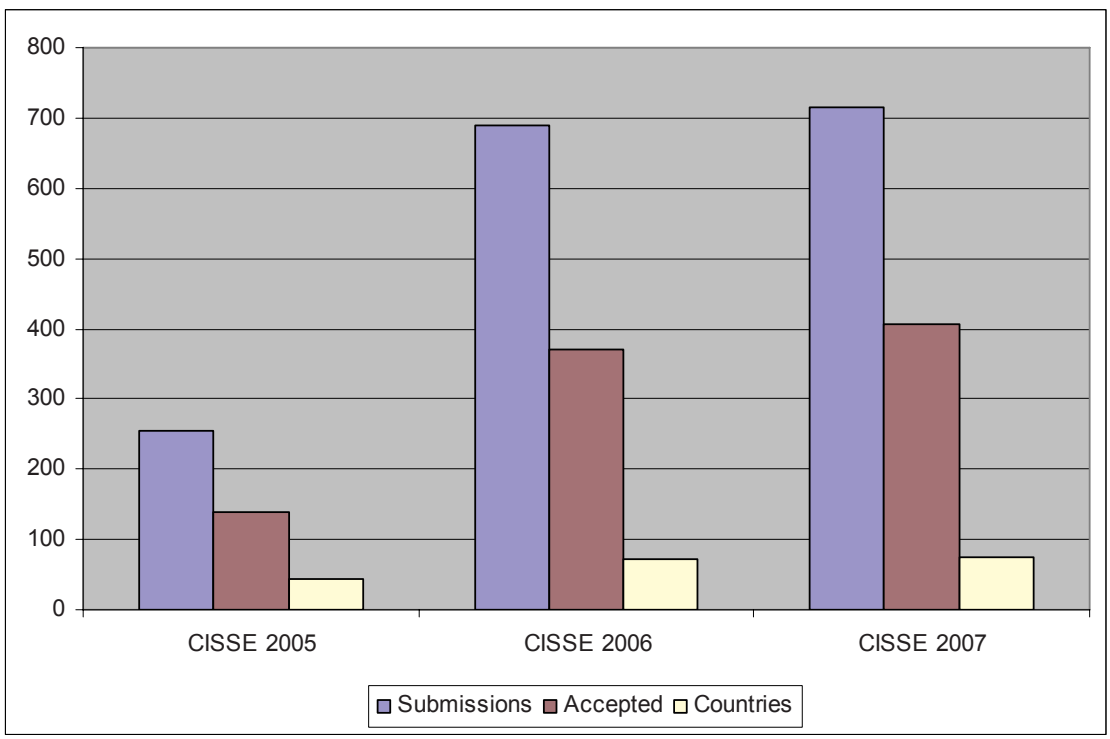


Figure 1: Participation at CISSE 2005, 2006 & 2007

mmeybodi@aut.ac.ir

The CISSE International Joint Conference is composed of the following four sub-conferences [2]:

1. International Conference on Industrial Electronics, Technology & Automation (IETA).
2. International Conference on Telecommunications and Networking (TeNe).
3. International Conference on Systems, Computing Sciences and Software Engineering (SCSS).
4. International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE).

The online structure of this high-quality event allows academic professionals and industry participants to contribute work and attend world-class technical presentations based on rigorously refereed submissions, live, without the need for investing significant travel funds. The CISSE international joint conferences completely eliminates secondary inhibiting factors such as the need for Visas, time out of office, costs associated with international travel, etc. Figure 1 shows a brief comparison of the participation at the three CISSE international conferences held till date. With every passing year the popularity, participation and caliber of the conference has been on a steady rise.

The CISSE Conference Platform

Conference participants - authors, presenters and attendees - only need an internet connection and sound (mic and speakers/headphones) available on their computers in order to be able to contribute and participate in this international ground-breaking conference. The virtual conference is conducted through the Internet using web-conferencing tools, made available by the conference. The CISSE conference platform provides superb audio even over low speed internet connections, the ability to display PowerPoint presentations, and cross-platform compatibility (the conferencing software runs on Windows, Mac, and any other operating system that supports Java).

Being a virtual platform, authors can present their PowerPoint, audio or video presentations using web-conferencing tools without exiting the comforts of their workplace. Figure 2 shows a snapshot of the CISSE web interface.

In addition, the conferencing system allows for an unlimited number of participants, which in turn granted us the opportunity to allow all CISSE participants to attend all presentations, as opposed to limiting the number of available seats for each session in regular conferences.

Conference presentations are broadcast in real-time to all conference participants. Session participants can interact with the presenting authors during or after the presentation. Usually CISSE provided for a 5 minute Question and Answer (Q&A) slot for participants to interact with the author. Non-author participants can also attend paper presentations of their choice and contribute by interacting with authors in this international conference.

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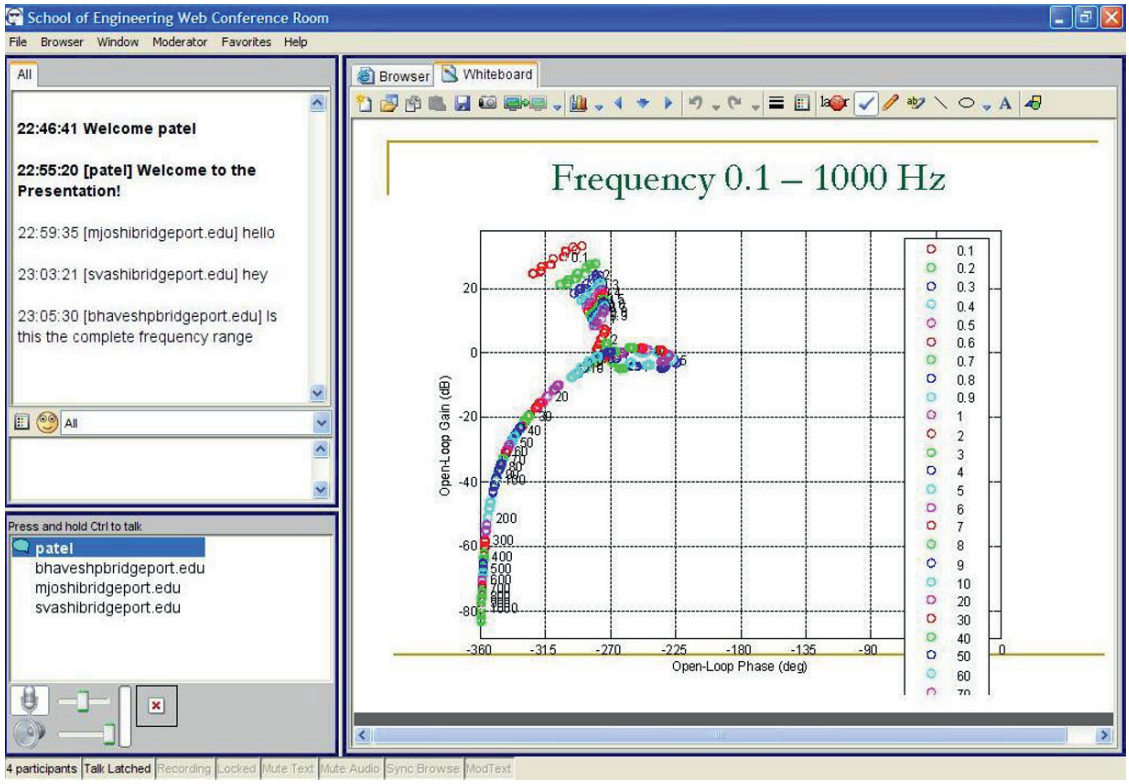


Figure 2: CISSE presenting author's interface

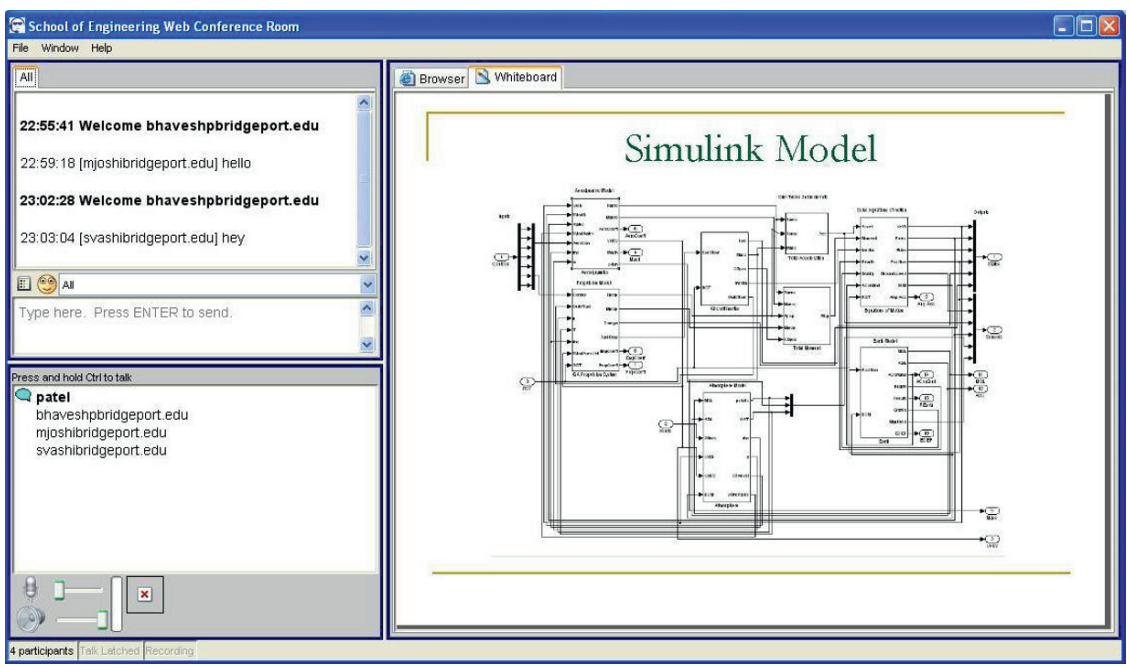


Figure 3: Conference attendee's interface

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Conference Management

Not only the conference itself but also all other aspects such as submissions, reviewing, and registration are managed online. Authors interested in participating in the conference can submit a paper to the CISSE conference by signing up on the CISSE website.

Each submission is review by a minimum of three technical committee members. The CISSE technical committees comprise of international leading researchers in their respective fields. Based on the suggestions of the reviews the Technical Chair of the conference makes the decision whether to accept or reject the submission.

The reviewers are assigned papers in their domain of research specialty by the technical chair preceiding over the conference. Reviewer can login to the conference website and view the papers assigned to them for review. The website presents the reviewer with feedback form for each paper to be reviewed.

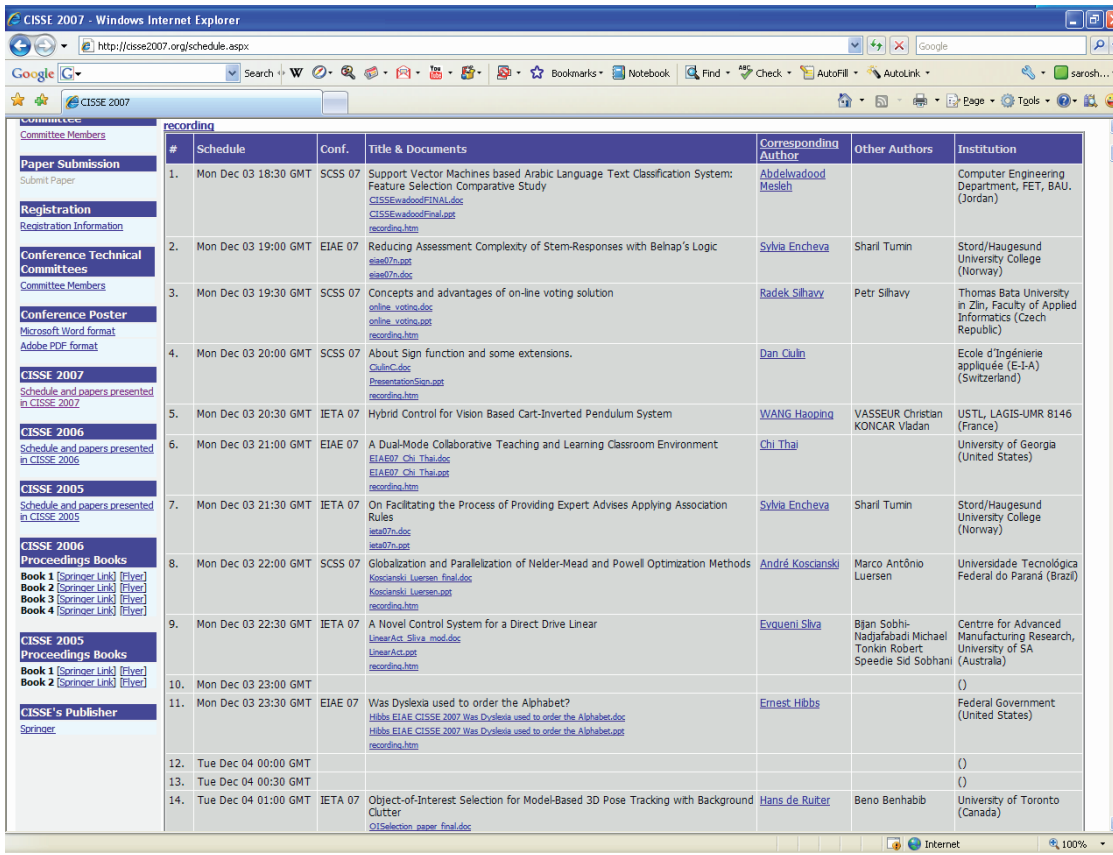


Figure 4: CISSE 2007 Conference Archive

The conference presentation schedule is prepared such that it is suitable to internationally participating authors from different time zones. Authors can pick the time slots most convenient to them for presenting their work. The only cost that is associated with CISSE is the conference registration fee once the manuscript has been accepted after a through review process.

The PowerPoint presentations, final paper manuscripts and time schedule for live presentations over the web are made available week prior to the start of the conference for all registrants, so that the participants can choose the presentations they would like to attend and think about questions that they might want to ask.

All the audio presentations are recorded and are part of the permanent CISSE archive which includes all power point presentations, papers and recorded audio presentations. Authors can always access the permanent archive by login in at the CISSE website

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with their login email and password. Figure shows the CISSE 2007 archive.

Conference registrants receive a copy of the DVD proceedings containing the PowerPoint presentations, audio presentations and the paper, and a hardcopy of the book proceedings from Springer. The CISSE proceedings are published in book by Springer, world's leading scientific publisher.

Conclusion

The conferencing technology implemented by the CISSE international conferences, starting with the submission and review system and ending with the online conferencing capability, allows for a very high quality, fulfilling event for all participants. CISSE encourages international participation by effectively removing barriers such as travel costs and time out of office.

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mmeybodi@aut.ac.ir

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