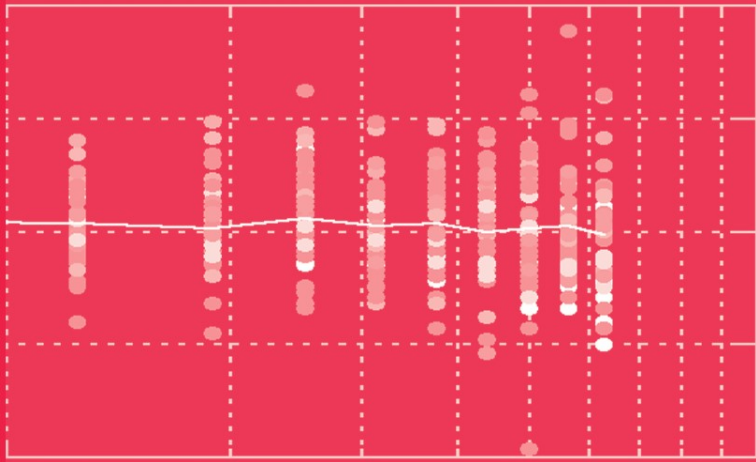


Magued Iskander
Editor



Innovations in E-learning, Instruction Technology, Assessment and Engineering Education



Springer

Innovations in E-learning, Instruction Technology,
Assessment, and Engineering Education

Innovations in E-learning, Instruction Technology, Assessment, and Engineering Education

Edited by

Magued Iskander, Ph.D., PE

Polytechnic University
USA

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To Sherry, Lolli, & Kito

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Preface

This book includes the proceedings of the 2006 International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE 06). EIAE 06 is part of the International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering (CISSE 06). 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 06 was a high-caliber research conference that was conducted online. EIAE 06 received 117 paper submissions and the final program included 80 accepted papers, from more than 35 countries, representing the six continents. Each paper received at least two reviews, and authors were required to address review comments prior to presentation and publication.

Conducting EIAE 06 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.

Maged Iskander. Ph.D., PE
New York, NY
June 2007

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The 2006 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, and Bill Taylor.

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: Ram Reddy, Sudhir Veerannagari, Elissa Seidman, Allen Wang, Abhilasha Tibrewal, Atef Al Najjar, Bill Taylor, Mohmoud Sawan, Abdollah Homaifar, Sarosh Patel, Paul Botosani, Alan Hadad, Selim Akl, Carlos Cabera, Amir Haddad, Eman Abdelfattah, Alexy Sidelev, Ilya Zarankin, Jack Victor, Jenney Lau, Mark Pytel, Margaret Cwikla, Mika Seppala, Kazunori Tabe, Vikram Kapila, Pooyan Aslani, Rola Maloof, Navarun Gupta, Nerik Yakubov, Nikhil Gupta, Noel Kriftcher, S. Karthikeyan, Chris Wilkins, William Kok, Edwin Yu, Mahmoud Mahmoud, Mahsa Rejei, Mary Cowman, Jay Lo, Hend Al-Khalifa, Haldun Hadimioglu, Farhan Mudasir, Gina Cooper, Alexander Vaninsky, Dino Kostarelos, Barry Stein, Alessio Gaspar, Amir Abdessemed, Gerhard Van Hyssteen, Jim Yaghi, Judy Serwatka, Md Maruf Hasan, Kaitung Au, Hara Mpouta, and Stanislaw Paul Maj.

Finally, I wish to gratefully acknowledge the support I received from 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., PE
New York, NY
June 2007

ROLE OF LDAP IN ENTERPRISE

Amrita Shukla
Lecturer, Electronics & Telecomm. Engg.
U.I.T. RAIPUR[C.G.]

Dr.A.S.Thoke
Prof. & H.O.D., Electrical Engg.
N.I.T. RAIPUR[C.G.]

Ms. Smita Shukla
Lecturer, Electrical Engg. Deptt.
N.I.T. RAIPUR[C.G.]

ABSTRACT

Lightweight Directory Access Protocol (LDAP) is a fast growing technology for accessing common directory information. LDAP has been embraced and implemented in most network-oriented middleware. As an open, vendor-neutral standard, LDAP provides an extendable architecture for centralized storage and management of information that needs to be available for today's distributed systems and services. After a fast start, it can be assumed that LDAP has become the de facto access method for directory information, much the same as the Domain Name System (DNS) is used for IP address look-up on almost any system on an intranet and on the Internet. LDAP is currently supported in most network operating systems, groupware and even shrink-wrapped network applications.

Introduction

People and businesses are increasingly relying on networked computer systems to support distributed applications. These distributed applications might interact with computers on the same local area network (LAN), within a corporate intranet, or anywhere on the worldwide Internet. To improve functionality, ease of use and to enable cost-effective administration of distributed applications

information about the services, resources, users, and other objects accessible from the applications needs to be organized in a clear and consistent manner. Much of this information can be shared among many applications, but it must also be protected to prevent unauthorized modification or the disclosure of private information. Information describing the various users, applications, files, printers, and other resources accessible from a network is often collected into a special database, sometimes called a directory. As the number of different networks and applications has grown, the number of specialized directories of information has also grown, resulting in islands of information that cannot be shared and are difficult to maintain. If all of this information could be maintained and accessed in a consistent and controlled manner, it would provide a focal point for integrating a distributed environment into a consistent and seamless system.

The Lightweight Directory Access Protocol (LDAP) is an open industry standard that has evolved to meet these needs. LDAP defines a standard method for accessing and updating information in a directory. LDAP is gaining wide acceptance as the directory access method of the Internet and is therefore also becoming strategic within corporate intranets. It is being supported by a

growing number of software vendors and is being incorporated into a growing number of applications.

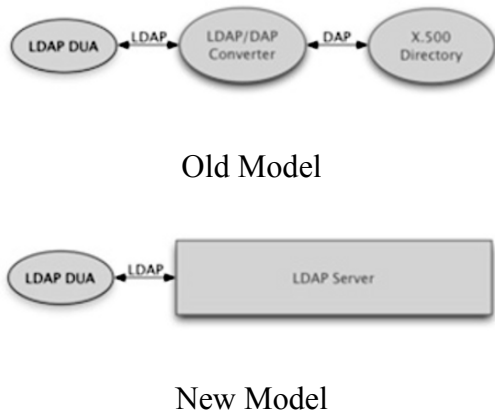


Fig. 1 Old And New Model of LDAP

What is a Directory?

A directory is a listing of information about objects arranged in some order that gives details about each object. Common examples are a city telephone directory and a library card catalog. For a telephone directory, the objects listed are people; the names are arranged alphabetically, and the details given about each person are address and telephone number. Books in a library card catalog are ordered by author or by title, and information such as the ISBN number of the book and other publication information is given.

In computer terms, a directory is a specialized database, also called a data repository, that stores typed and ordered information about objects. A particular directory might list information about printers (the objects) consisting of typed information such as location (a formatted character string), speed in pages per minute (numeric), print streams supported (for example PostScript or ASCII), and so on.

Directories allow users or applications to find resources that have the characteristics needed for a particular task. For example, a directory of users can be used to look up a person's e-mail address or fax number. A directory could be searched to find a nearby PostScript color printer. Or a directory of application servers could be searched to find a server that can access customer billing information. The terms white pages and yellow pages are sometimes used to describe how a directory is used. If the name of an object (person, printer) is known, its characteristics (phone number, pages per minute) can be retrieved. This is similar to looking up a name in the white pages of a telephone directory. If the name of a particular individual object is not known, the directory can be searched for a list of objects that meet a certain requirement. This is like looking up a listing of hairdressers in the yellow pages of a telephone directory. However, directories stored on a computer are much more flexible than the yellow pages of a telephone directory because they can usually be searched by specific criteria, not just by a predefined set of categories.

Differences Between Directories and Databases

A directory is often described as a database, but it is a specialized database that has characteristics that set it apart from general purpose relational databases. One special characteristic of directories is that they are accessed (read or searched) much more often than they are updated (written). Hundreds of people might look up an individual's phone number, or thousands of print clients might look up the characteristics

of a particular printer. But the phone number or printer characteristics rarely change. Because directories must be able to support high volumes of read requests, they are typically optimized for read access. Write access might be limited to system administrators or to the owner of each piece of information. A general purpose database, on the other, hand needs to support applications such as airline reservation and banking with high update volumes. Because directories are meant to store relatively static information and are optimized for that purpose, they are not appropriate for storing information that changes rapidly. For example, the number of jobs currently in a print queue probably should not be stored in the directory entry for a printer because that information would have to be updated frequently to be accurate. Instead, the directory entry for the printer could contain the network address of a print server. The print server could be queried to learn the current queue length if desired. The information in the directory (the print server address) is static, whereas the number of jobs in the print queue is dynamic. Another important difference between directories and general purpose databases is that directories may not support transactions (some vendor implementations, however, do). Transactions are all-or-nothing operations that must be completed in total or not at all. For example, when transferring money from one bank account to another, the money must be debited from one account and credited to the other account in a single transaction. If only half of this transaction completes or someone accesses the accounts while the money is in transit, the accounts will not balance. General-purpose databases usually

support such transactions, which complicates their implementation.

Because directories deal mostly with read requests, the complexities of transactions can be avoided. If two people exchange offices, both of their directory entries need to be updated with new phone numbers, office locations, and so on. If one directory entry is updated, and then other directory entry is updated there is a brief period during which the directory will show that both people have the same phone number. Because updates are relatively rare, such anomalies are considered acceptable. The type of information stored in a directory usually does not require strict consistency. It might be acceptable if information such as a telephone number is temporarily out of date. Because directories are not transactional, it is not a good idea to use them to store information sensitive to inconsistencies, like bank account balances. Because general-purpose databases must support arbitrary applications such as banking and inventory control, they allow arbitrary collections of data to be stored. Directories may be limited in the type of data they allow to be stored (although the architecture does not impose such a limitation). For example, a directory specialized for customer contact information might be limited to storing only personal information such as names, addresses, and phone numbers. If a directory is extensible, it can be configured to store a variety of types of information, making it more useful to a variety of programs.

Another important difference between a directory and a general-purpose database is in the way information can be accessed. Most databases support a standardized, very powerful access

method called Structured Query Language (SQL). SQL allows complex update and query functions at the cost of program size and application complexity. LDAP directories, on the other hand, use a simplified and optimized access protocol that can be used in slim and relatively simple applications.

Because directories are not intended to provide as many functions as general-purpose databases, they can be optimized to economically provide more applications with rapid access to directory data in large distributed environments. Because the intended use of directories is restricted to a read-mostly, no transactional environment, both the directory client and directory server can be simplified and optimized.

Directory Clients and Servers

Directories are usually accessed using the client/server model of communication. An application that wants to read or write information in a directory does not access the directory directly. Instead, it calls a function or application programming interface (API) that causes a message to be sent to another process. This second process accesses the information in the directory on behalf of the requesting application. The results of the read or write are then returned to the requesting application (see Figure 2).

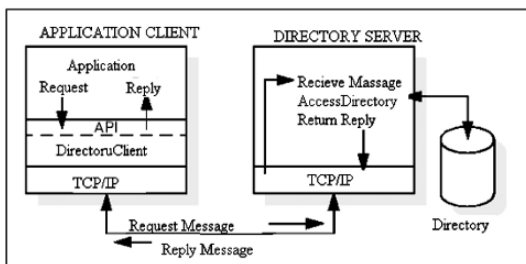


Figure 2. Directory Client / Server System

The request is performed by the directory client, and the process that

looks up information in the directory is called the directory server. In general, servers provide a specific service to clients. Sometimes a server might become the client of other servers in order to gather the information

necessary to process a request. A directory service is only one type of service that might be available in a client/server environment. Other common examples of services are file services, mail services, print services, Web page services, and so on. The client and server processes might or might not be on the same machine. A server is capable of serving many clients. Some servers can process client requests in parallel. Other servers queue incoming client requests for serial processing if they are currently busy processing another client's request. An API defines the programming interface a particular programming language uses to access a service. The format and contents of the messages exchanged between client and server must adhere to an agreed upon protocol. LDAP defines a message protocol used by directory clients and directory servers. There is also an associated LDAP API for the C language and ways to access LDAP from writhing a Java application. The client is not dependent upon a particular implementation of the server, and the server can implement the directory however it chooses.

Directory-Enabled Applications

A directory-enabled application is an application that uses a directory service to improve its functionality, ease of use, and administration. Today many applications make use of information that could be stored in a directory. For example, consider a group calendar application that is used to schedule

meetings of company personnel in different conference rooms. In the worst case, the calendar application does not use a directory service at all. If this were the case, a user trying to schedule a meeting would have to remember the room number of every conference room that might be appropriate for the meeting. Is the room big enough, does it have the necessary audio and video equipment, and so on? The user would also have to remember the names and e-mail addresses of every attendee that needs to receive a meeting notice. Such an application would obviously be difficult to use. If conference room information (size, location, special equipment, and so on) and personnel information (name, e-mail address, phone number, and so on) could be accessed from a directory service, the application would be much easier to use. Also, the functionality of the application could be improved. For example, a list of all available conference rooms meeting the size and equipment requirements could be presented to the user. But the developers of directory-enabled applications are faced with a problem. What if they cannot assume that a directory service will exist in all environments? If there is a directory service it might be specific to a certain network operating system (NOS), making the application non-portable. Can the existing directory service be extended to store the type of information needed by the application? Because of these concerns, application developers often took the approach of developing their own application-specific directory.

Conclusion

Lightweight Directory Access Protocol (LDAP) is a fast growing technology for

accessing common directory information. LDAP has been embraced and implemented in most network-oriented middleware. As an open, vendor-neutral standard, LDAP provides an extendable architecture for centralized storage and management of information that needs to be available for today's distributed systems and services.

Another very important role for LDAP in Active Directory is that of cross-platform access interface. LDAP is not tied to a particular platform as is ADSI, which is COM-based and therefore tied to Windows. That means applications and scripts can be written to access and manage Active Directory from virtually any platform. This is a huge improvement over Windows NT4 where access was limited to the Win32 API, which for the most part can only be used from the Windows platform. LDAP allows companies that have a non-Windows-based enterprise management infrastructure the ability to populate, maintain, and monitor Active Directory from the platform of choice.

With LDAP Version 3, a solid foundation for a directory service infrastructure for the Internet was built. As we have seen in previous chapters, most vendor implementations are based on this version or have most features of Version 3 incorporated. But there is still room for enhancements, for example in areas of API support for other program languages, like Java. To define these standards, members of the Internet Engineering Task Force (IETF) work on and submit draft proposals that eventually might become Request for Comments (RFCs). The RFCs describe the idea and the implementation of the major design and technologies for the new functions and features. We describe

some important proposed enhancements in the next section. Although there is not a specific section in this book devoted to it, it should be mentioned that the vendor products will of course be further developed and enhanced, namely in areas such as improved functionality, manageability, and performance. For example, client-side caching could be implemented to improve performance remarkably, especially on multi-user client systems with heavy directory access. Graphical management tools can be added, or existing GUIs may be improved that allow easy configuration and contents management. As LDAP matures to a de facto standard, it will eventually replace proprietary directory services in vendor products and other standardized middleware solutions, such as the Distributed Computing Environment (DCE). DCE makes heavy use of a directory service and currently uses its own, specific implementation, called Cell Directory Service (CDS).

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Engineering modelling in transfer function form: an active learner approach

Aidan O'Dwyer,

School of Control Systems and Electrical Engineering,
Dublin Institute of Technology, Kevin St., Dublin 8, Ireland.

Abstract- Traditionally, the modelling of real systems in engineering, using transfer functions, has been done in a mathematically intense manner. However, non-traditional learners such as mature students, part-time students and students without a conventional second-level educational background may not have strong mathematical foundations; in addition, all students increasingly expect technical work which is practical and which motivates independent learning. This paper reports on, reflects on and evaluates an innovative experiment developed by the author to estimate a transfer function model of a persons' eye-brain-hand motor response. In the experiment, carried out using a PC with data acquisition capability, the person is successively asked to track, with a mouse, ten sine wave signals at different frequencies on a computer screen. Based on an average of the data recorded, the person's eye-brain-hand motor response in the frequency domain is recorded (and may be summarized on a Bode plot). Subsequently, the parameters of a single input, single output (SISO) process model may be determined, using an analytical technique.

I. INTRODUCTION

Significant effort has been devoted to determining a model for the human operator in a simple closed loop system. Early work was reported in 1947 [1], [2]; the non-linear nature of the model required was recognised. Reference [3] reports that, to model the human tracking response, "it has become customary to treat the problem with some linear time invariant approximate transfer function that will help account for at least some of the empirical facts." The authors suggest the following transfer function model:

$$G_m(s) = \frac{K_m(1 + T_{m1}s)e^{-s\tau_m}}{(1 + T_{m2}s)(1 + T_{m3}s)}, \quad (1)$$

with τ_m being the reaction time delay, $\tau_m \in [0.2, 0.5]$ seconds; $T_{m1} \in [0.25, 2.5]$ seconds; T_{m2} is the neuromuscular lag for the arm, $T_{m2} \in [0.1, 0.16]$ seconds; $T_{m3} \in [5, 20]$ seconds; K_m is the (variable) model gain. Such a model was also developed by Alexik [4]. Extensive work on modelling of neurological control systems is presented by Stark [5]; in elegant experiments, the author determines, for example, frequency response plots for the dynamic characteristics of the human motor co-ordination system and frequency response plots of the control system of the human hand. In other work in the frequency domain, transfer functions for human tracking response based on a one-dimensional, sine wave tracking experiment are developed [6]. A joystick is used to allow tracking of the sine wave. The model transfer

function developed is second order, with one zero, and a time delay. The authors quote representative values of the model gain as being from 1 to 100; representative values for the two model poles are from 0 to 20s and $0.1s \pm 20\%$, respectively; the representative value for the model zero is from 0 to 2.5s; the representative model time delay is $0.2s \pm 20\%$. In another contribution, Hess [7] suggests that a human in a control loop may be modelled as either an integrator plus time delay model or a third order model with one pole, one zero and a time delay. If the human is modelled as an integrator plus time delay model, the author suggests that the equivalent time delay is approximately 0.27s, with the equivalent time delay being equal to approximately 0.15s when the human is modelled in third order plus delay form.

The origin of the individual terms of the model in the physiological and psychological condition of the human operator has also been mooted. For example, Hess [7] suggests that the time delay represents the cumulative effect of actual time delays in the human information processing system (e.g. visual detection times, neural conduction times), the low frequency effects of higher frequency human operator dynamics (e.g. muscle actuation dynamics) and higher frequency dynamics in the controlled element itself. In reference [8], it is stated that delay time in a human operator is primarily a result of transport delays and central nervous system latencies. The authors also state that, depending on the input bandwidth, the delay may include neuromuscular lag and a time varying component that depends on factors such as attention level and task difficulty.

In a wider discussion of the measurement of sensory-motor control performance capacities, Jones [9] suggests that the use of sinusoidal tracking signals is valuable for the study of the human frequency response; in particular, the "periodicity, constancy of task complexity (over cycles) and spectral purity of sine targets" are useful for detecting changes in performance (such as learning or lapses in concentration) within an experimental run. A number of references are quoted.

The experimental work reported in this paper has been inspired primarily by the work of references [5] and [6]. As an alternative to the use of a joystick [6], it has been decided to track sine waves, at different frequencies, on a computer screen using the PC mouse. The subsequent transfer function models, deduced from the frequency response data, have been developed using an analytical method, as proposed by O'Dwyer [10]. The analytical method is based on direct

calculation of the parameters from the frequency response, using simultaneous equations.

II. EXPERIMENTAL DETAILS

The experiment is carried out using a personal computer with a data acquisition card and suitable software (MATLAB/SIMULINK and HUMUSOFT) to record the input sine wave (generated in SIMULINK) and the persons' tracking sine wave. The implementation in SIMULINK is shown in Fig. 1.

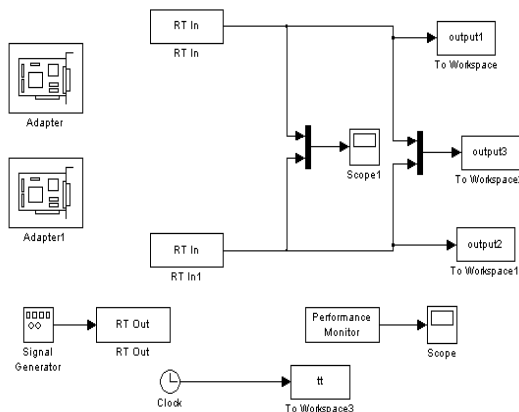


Fig. 1. SIMULINK implementation

The person is requested to track, with a mouse, ten sine wave signals at frequencies from 0.1 Hz to 1 Hz, in steps of 0.1 Hz, on a computer screen. Six cycles of the sine wave are tracked at any one frequency. A typical example of one sine wave input signal (at a frequency of 0.1 Hz), and a person's tracking attempt, is shown in Fig. 2. As expected, subjects tended to have little difficulty in tracking such slow signals; as the frequency of the input signal increased, tracking difficulties also increased.

The magnitude (i.e. the ratio of the amplitude of the output and input signals) and the phase difference between the output and input signals (labeled as phase 1, phase 2 etc. on Fig. 2), were recorded at the ten individual frequencies. Based on an average of the magnitudes and phase differences recorded, a Bode plot is drawn from the data, and a transfer function for the motor response is developed from the plotted data. Specifically, the amplitude is taken over an average of four cycles, ignoring data from the first and last cycle. The phase is taken as the average of the four phases indicated in Fig. 2; again, the early-recorded data is ignored. Such early data tends to be less reliable, as experience had shown that the user needs a short time to adjust to the frequency of the input signal.

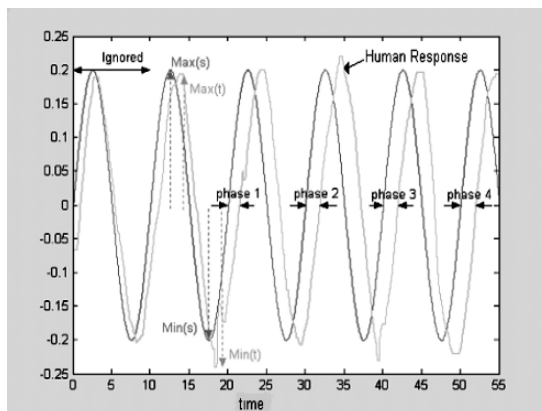


Fig. 2. Typical tracking attempt

III. EXPERIMENTAL RESULTS

A series of experimental results have been collated. Altogether, since the programme was developed, seventy-six sets of data have been gathered. Some of these sets of data have had to be excluded from the analysis, as, despite instructions to track the data after it becomes visible on the screen, in some cases subjects predicted the very regular sine wave input. Further work is required on the algorithm to minimise this problem.

After the data mentioned above was excluded, 54 data sets remained. Data was gathered when tracking was done with both the dominant and non-dominant hand. The data gathered can be classified as follows:

1. Data gathered in May 1999 from a 36 year old male (myself). Three sets of data were gathered for the dominant hand and two sets of data were gathered for the non-dominant hand.
2. Data gathered in January 2006, in the early morning and late evening, from a 42 year old male (myself). Fourteen sets of data were gathered for the dominant hand and thirteen sets of data were gathered for the non-dominant hand.
3. Data gathered from May 1999 to January 2006 from both male and female students, with a typical age of 21 years. Twenty sets of data were gathered for the dominant hand and six sets of data were gathered for the non-dominant hand.
4. Data gathered in May 1999 from an older group of subjects. This is non-dominant hand data.

Fig. 3 shows the Bode plot of all the data gathered. Magnitude is measured in decibels (dB) with phase measured in degrees. Table 1 gives the average data, at angular frequency ω (phase ϕ_p is measured in radians and magnitude $|G_p|$ is recorded in non-decibel format).

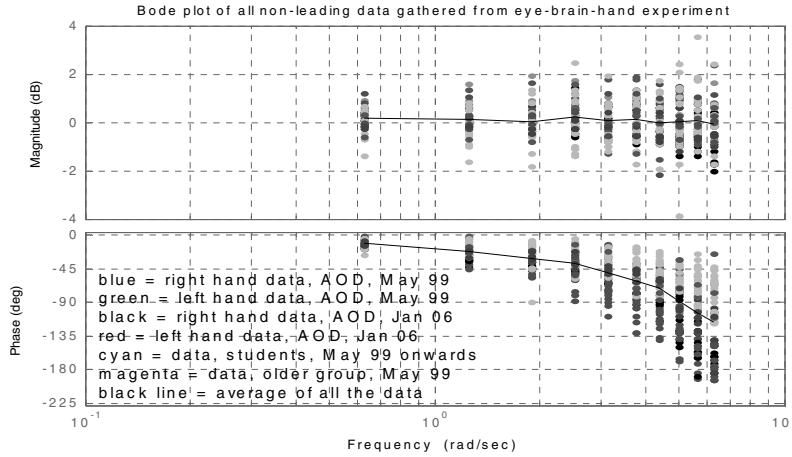


Fig. 3. Bode plot of all the data gathered

TABLE 1
AVERAGE OF THE DATA

ω (rads/s)	0.68	1.30	1.90	2.56	3.14	3.81	4.33	5.03	5.70	6.28
ϕ_p (rads)	-0.20	-0.39	-0.55	-0.66	-0.87	-1.08	-1.25	-1.55	-1.82	-2.03
$|G_p|$	1.02	1.01	1.00	1.02	1.01	1.01	1.00	1.01	1.01	0.99

It should be noted that the resolution possible on the phase varies with frequency, as the sample time of 0.05 seconds used to gather the data is the minimum possible with the data acquisition card and software used. The resolution on the phase is 0.031 radians at $\omega = 0.68$ rads/s, rising linearly to 0.314 radians at $\omega = 6.28$ rads/s. As phase varies almost linearly with frequency, the resolution in phase as a percentage of the phase recorded is approximately constant at 16%.

On application of the analytical method of transfer function determination [10], it was discovered that, on average, that the data could be modelled by a gain term, K_m (which depends on the magnitude), and a reaction time

delay term, τ_m (which depends on the phase). In addition, as Table 1 reveals, K_m is approximately 1, even at higher frequencies. This means that subjects tend to be able to track the amplitude of the sine wave accurately. Thus, overall, the data may be summarized by a delay term, which may be determined as 0.30 seconds. After adjusting for the sample time of 0.05 seconds, the average eye-brain-hand motor response reaction time is recorded as 0.25 seconds.

Table 2 summarizes results obtained from a more detailed analysis of the data. The delay determined could be expected to have a maximum inaccuracy of 16%.

TABLE 2
SUMMARY OF RESULTS OBTAINED

Condition	Delay determined
Average of all data gathered	0.25 s
Average, dominant hand data, male/female students, May 1999 – Jan. 2006	0.14 s
Average, dominant hand data, 22 year old male, May 1999	0.16 s
Average, dominant hand data, 36 year old male (myself), May 1999	0.20 s
Average, dominant hand data, 42 year old male (myself), January 2006	0.32 s
Average, non-dominant hand data, 22 year old male, May 1999	0.19 s
Average, non-dominant hand data, male/female students, May 99 – Jan. 06	0.20 s
Average, non-dominant hand data, 42 year old male (myself), January 2006	0.41 s

Clearly, the delay recorded, on average, increases with age; on average, there is also an increase in reaction time required if the non-dominant hand is used. Both of these results are intuitively expected.

Other results showed that there were no significant differences in reaction times recorded when

- Data were gathered in the morning (07:55-12:11) versus data being gathered in the late evening (20:00-21:20)
- Data were gathered from male and female students and compared.

IV. PEDAGOGICAL ISSUES

Since its development in 1999, this experiment has been carried out by students taking a control engineering option in the programmes in electrical/electronic engineering at Dublin Institute of Technology. Traditionally, the modelling of real systems in engineering, using transfer functions, has been done in a mathematically intense manner. However, non-traditional learners such as mature students, part-time students and students without a conventional second-level educational background may not have strong mathematical foundations; in addition, all students increasingly expect technical work which is practical and which motivates independent learning. The author has found that students are enthusiastic about the experiment and frequently spend over the allocated time on aspects of it.

The following questionnaire was distributed to a group of students performing the experiment in the 2005-6 academic year, to get formal feedback on their experiences with the experiment.

Please answer the following questions. To answer each question, please write a number between 1 and 5, with

5 - strongly agree; 4 - agree; 3 - unsure; 2 - disagree
1 - strongly disagree

1. The work was a beneficial learning experience (compared to other exercises).
2. The work is user-friendly.
3. The work complements and enhances my understanding of lecture material.
4. The work is fun and sustained my interest.
5. I became more interested in the material because of this work.
6. There is enough time to perform the work.
7. I would recommend this work to others.
8. Any other comments.

When the feedback was analysed, students agreed with the statements that:

- The work was a beneficial learning experience (compared to other exercises) – average number: 4.3.
- The work is user-friendly – average number: 4.2.
- The work complements and enhances my understanding of lecture material – average number: 4.5.

- The work is fun and sustained my interest – average number: 4.5.
- I became more interested in the material because of this work – average number: 4.0.
- I would recommend this work to others – average number: 4.3.

Students were unsure about the statement that “There is enough time to perform the work” (average number: 3.0).

Overall, student feedback is encouraging; the reasons for this, in the author’s opinion, are

- The experiment provides direct feedback to the user on the PC screen.
- The experiment is not excessively time-consuming; a typical experiment time to gather one set of data, at 10 frequencies, is 10 minutes.
- A competitive edge among (typically, male) students is frequently observed, with a desire to have the shortest reaction time.
- A motivational aspect for some students is the application of the idea in biomedical engineering, possibly in the diagnosis of some motor response disorders; as the experiment provides direct feedback to the user on the PC screen, it lends itself to providing motivation to a person attempting to regain motor function after a neurological setback, such as a stroke.

However, the experiment is somewhat tedious to carry out because of its repetitive nature. In addition, as mentioned, it is possible for subjects to predict, rather than track, the very regular sine wave inputs.

V. CONCLUSIONS AND FUTURE WORK

The paper reports on the estimation of a simple transfer function model of a persons’ eye-brain-hand motor response, using an innovative experiment. The data from the experiment may be analysed by the students to determine the transfer function model (for those students with the required mathematical foundations). Alternatively, for students without such foundations, the data may be imported into a programme written by the author in MATLAB and the transfer function model results. The experiment is practical, though somewhat tedious to carry out. For future work, the use of a less predictable alternative to the sine wave signal would be desirable.

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PCML: A Pedagogy-oriented Content Markup Language

Akshay Kumar, Sasikumar M

Education Technology Division,
Centre for Development of Advanced Computing ,
Kharghar, Navi Mumbai-400614
India
{akshay, sasi}@cdacmumbai.in

Abstract—Online learning requires learning material to be made available in a suitable manner over a network. Content Management System (CMS) [1] helps in making the learning materials organized and accessible in some intelligent fashion online. Content creation for a CMS requires two roles of people, teacher and content developer. Content developer interacts with teacher for getting content. Content developer then formats and places content into a CMS. This interaction between teacher and content developer is manual and depends on their personal experience.

Pedagogy-oriented Content Markup Language (PCML) is an effort to automate this interaction between teacher and content developer. PCML defines a set of tags, for tagging content, based on the pedagogic role of a particular part of content. Content developer can then use this tagged content (developed by teacher) to develop contents for a specific Content Management System. It also addresses many other issues in content development like reusability, personalization and minimal loss of information.

I. BACKGROUND

Use of CMS for delivering content online is now common. There are many CMS in market, including Moodle, Drupal etc. CMSs normally address features related to content creation, content management and content delivery. Content creation in a CMS is concerned with obtaining the actual content to be taught (core content) and organizing them in pedagogically appropriate manner. Core content is fetched from content in file, from another CMS, or manual interaction of content developer to the teacher. Core content in file and in another CMS also results by manual interaction of content developer and the teacher. There are many conversion tools (for example, MS Word to XML converter), and migration tools (across CMS) which is useful for creating content from the existing content for different CMSs and these tools are generally specific to individual CMS. There is little work on the automation of the

manual interaction of content developer to the teacher for getting core content at first level.

Content developer interacts with the teacher for developing the content in a CMS. Content developer applies his/her intuition to capture the requirements of the teacher and customize the content for a specific CMS. These interactions between teacher and content developer are not defined properly, and are often carried out through largely ad-hoc personal interactions and discussions. Thus instructions given by teacher and customization done by content developer on the basis of the interactions are purely dependent on the capability of the teacher and the content developer. This situation makes scope for loss of information during development of the content and makes the task time consuming.

There is another problem with this approach. For developing the same content in different CMS, teacher gives same information about the content to content developers again and again. The content developers associated with the different CMSs, however, need to adopt these contents differently to match the features provided by the respective CMSs and the type of data storage mechanism followed by them. It is annoying to repeat the same task, for the teacher. There should be some means by which teacher can place all the information to the content developer. Teacher should be able to specify the content, just once, in terms that he/she is comfortable with, namely concepts, example, code, explanations, etc; dependency between the parts of the content and any restriction on the content. Any content developer can use this specification directly to create content for a specific CMS. This will also reduce the loss of information during the content development.

In this paper, we propose the use of a markup language keeping these issues in mind. The language is meant to be used by the teacher directly with no specific technology skills. Content in this language can be semi-automatically translated to various different CMSs. In section 2, we expand on the need for a markup language, stressing its advantages. Section 3 and 4 outlines the language and our methodology to design of the language. Section 5 summarizes our experience with this language and concludes the paper.

II. NEED FOR A MARKUP LANGUAGE

We propose a markup language [2] named Pedagogy-oriented Content Markup Language (PCML) for use by teacher. Teacher will be able to embed information about content as per his/her requirements while creating the content in PCML, using terms that he/she is comfortable with and focus on aspects and issues that he want to be concerned about. This

will help to automate the process of interaction of teacher and content developer. Now, teacher need not interact directly with the content developer. Content developer will take content specified in PCML adopting it to his/her CMS. Thus, it will separate the areas of concern of a teacher and a content developer. Now, the teacher and the content developer will work separately and efficiently. Content developed in this language by the teacher is a one time job and can be used by content developer for different CMSs.

In Fig. 1, we show the conventional method of content development. Content developer interacts with the teacher and develops the content in a CMS or Content developer interacts with the content of one CMS and transforms it into another CMS. In Fig. 1, let us assume that the loss of information during first development is ∂x and the loss during the conversion of content in one CMS to other CMS is ∂y . Hence, the loss during conversion of content in second and third steps is ∂y . So, the average loss of information per CMS during content development in three CMSs is $\partial x + \partial y$. In Fig. 2, where each content developer interacts directly with teacher separately, the average would be ∂x . However, there is significant overhead on the teacher.

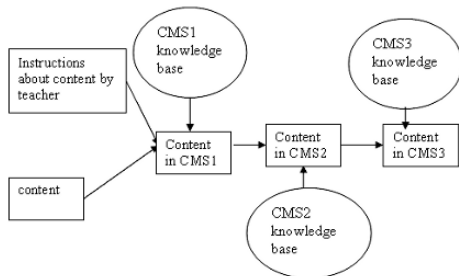


Fig. 1 Transformation of Content across CMSs

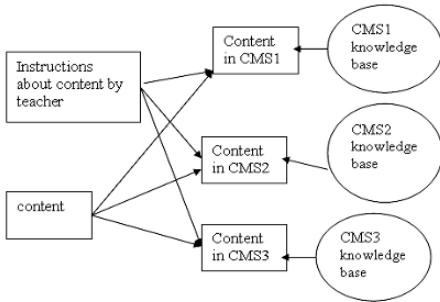


Fig. 2 Independent Generation of Content in Various CMSs

In Fig. 3, we are showing the method of content development using the proposed language. In this situation, depicted in the Fig. 1, the loss of information per CMS would be $\partial z + \partial a$ (where $\partial z + \partial a \leq \partial x$), where ∂z is the loss of information while placing content inside the specified PCML and ∂a (its value will decrease with the increase of expertise of content

developer) is the loss of information during the conversion of content specified PCML to the specific CMSs. It eventually tends to zero as PCML gets refined.

We know that markup language is useful to encode data in the desired format with minimal loss of information. We have such requirement for encoding content in the perspective of the teacher. PCML is designed as markup language to capture the requirement of the teacher. Teacher can specify information using pedagogic terms familiar to them. For example, a particular piece can be tagged as an example or a question.

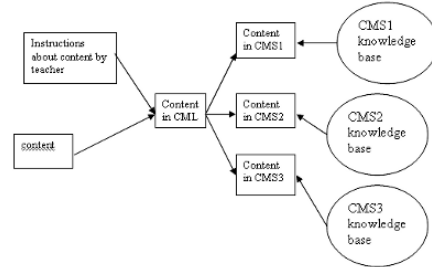


Fig. 3 Proposed Model using Markup Language

We have chosen pedagogic concepts in content as the basic to create the language. This makes it convenient for teacher to learn the language faster, and they don't need to identify ways of mapping their content into terms that they don't deal with. In addition, PCML also enables adapting instruction to various learner requirements. It is relatively easier to identify what can be omitted when presenting content on a device with limited screen area and also to choose the appropriate type of example and even number of examples for different learners.

III. DESIGN OF PCML

PCML uses XML [3] (Extensible Markup Language) as the base markup language to ease design of PCML. Some existing markup languages which use XML are: MathML [4] for representing mathematical constructs such as equations and formulae, NewsML [5] for representing news, and RuleML [6] for representing 'if then' rules in a knowledge base.

For initial design of PCML, content of schools and colleges were examined. It is delivered to the student mainly as textbook, slides, movie files, images etc. It has been found that these contents could be divided into entities such as subject, resource, section, sub section, images, example etc.

A close examination of any content meant for learning reveals a number of elements. The discovery of such elements, entity sequencing, entity nesting and organization and their attributes are required. These can be categorized into the following broad classes:

- The core content element (CCE): These are the semantically atomic level content. These include elements such as a movie clip, an image, a definition, an example, a code segment, an animation, etc. While syntactically, these are all to be displayed as a single unit, it is important to distinguish the different CCEs. These distinctions provide the delivery system with a

lot of useful information. For example, it can identify what is mandatory to provide (an example or anecdote can be skipped if there is lack of space or when in a review mode) and what can be omitted. It can choose consistent rendering styles for various CCEs, so that all examples are flagged in a consistent way. This also enables the system to identify the relevant software to be used for rendering.

- The organizing elements (OE): These are elements which help to hold together a set of lower level content elements. Each lower level element may, in turn, be another organizing element or a CCE. These include constructs such as section, list, etc. The OEs are primarily to provide sequencing constraints (for example, constituents of this must be delivered in the order specified; the constituents of this are alternatives from which one may be chosen, etc).
- The referencing elements (RE): These are elements which enable reuse of the content inside core content element and content inside organizing elements.

We examined some sample lessons from select curricular material to identify the various kinds of elements that are used from all these categories. The content of the NCERT science and technology text book of Xth standard [7] has been taken for testing the content markup language. The organization of a chapter in the book is as follows. It is divided into sections. Each section has subsections. Each subsection has resources, paragraphs, pictures and further subsections. Resources can have tabular data related to the topic. Some notes and activities also have been included to make the mapping of content and teacher's view synchronized and clear. The activities are for the application of learning through doing some practical experiments. Resources also have some derivation of the formulas with related example as questions and solutions.

We noticed a number of CCEs including term, symbol, abstract, example, question, answer etc. and a number of OEs such as section, resource, list, bag, alt etc. Note that OEs include very high level constructs such as chapter, section, etc and relatively low level constructs such as ordered list.

Based on the primitives we identified, we designed the first version of the language and attempted to write down the examined content using these primitives. An XML DTD was also created. We also picked some additional content and encoded using the language. Overall, we found that the primitives are powerful and adequate. Based on specific feedback received, we revised the language changing a few of the primitives introduced.

In the next section, we briefly describe the language as it exists today.

IV. A BRIEF LOOK AT THE LANGUAGE

All PCML elements fall into the categories as mentioned in previous section based on their uses:

A. Core content elements:

These tags are used for defining term or symbols or core content. The following are the tags included this category: term, symbol, abstract, annotation, answer, article, audio, citation, equation, example, overview, question, remark, subject,

summary, text, caption, title, tip, video, warning, image, code, data, comment, conclusion, and note. For example:

```
<warning display="must">
  Do not see sun with naked eyes
```

```
</warning>,
<code language="java">
  int i=0;
  int j=56;
  System.out.println (i+j);
```

```
</code>,
<citation typeOf='textbook' annotation_no='16'>
```

Bryan, Martin, SGML: An Author's Guide to the Standard Generalized Markup Language, Addison Wesley, 1988

```
</citation> etc.
```

B. Organizing elements:

These tags are used for organizing different content in a group. The following are the tags included into this category: section, resource, list, bag, alt, req and multimedia. For example, the following specifies two alternative forms of displaying the days of week.

```
<alt>
  <req>
    <text>Monday</text>
    <text>Friday</text>
    <text>Tuesday</text>
    <text>Wednesday</text>
    <text>Sunday</text>
    <text>Thursday</text>
    <text>Saturday</text>
  </req>
  <req>
    <text>lundi</text>
    <text> mardi </text>
    <text> mercredi </text>
    <text> jeudi </text>
    <text> vendredi </text>
    <text> samedi </text>
    <text> dimanche </text>
  </req>
</alt>
```

C. Referencing elements:

These tags are used for making reusable content across the PCML. The following are the tags included into this category: include and link. For example:

```
<resource nameid="xyz3">
  <multimedia>
    <caption>The New Cartesian Sign
      Convention for reflection
      of light by spherical mir-
      rors.
    </caption>
```

```

        <image
          src="images/sign_image.bmp" />          <include from="xyz3" />
      </multimedia>
</resource>

```

Fig. 4 shows a snippet of content illustrating some of CCE and OE tags.

At a different place, we can write

```

<section nameid="sec_0002_01_01" name="REFLECTION OF PLANE MIRRORS">
  <resource>
    <title>Reflection By Plane Mirrors</title>
    <text>
      An extended object AB, of height (size)
      ....
      to move its left hand.
    </text>
    <question>
      What are the values of angle of incidence ( $i$ ) and that of
      reflection ( $r$ ) for a normal incidence?
    </question>
    <question>
      <text>See</text>
      <multimedia>
        <caption>
          Fig. 3.1: An extended object AB and its virtual image
          A'B' formed in a plane mirror MN
        </caption>
        <image src="images/image3.1.bmp" name="Fig.3.1">
        </image>
      </multimedia>
      <text>
        And with the help of congruent triangles, show that  $A'C = AC$ 
        and  $A'B' = AB$ . Interpret the results.
      </text>
    </question>
  </resource>
</section>

```

Fig. 4 Sample content in proposed PCML

V. USE OF PCML

Content in PCML needs to be converted into structure and format of various CMS for use in practice. We expect that using a knowledge base, mapping the various constructs of PCML to suitable directories and File structures of a specific CMS, we can automate fair amount of this work. Such a knowledge base will necessarily be CMS specific. This model simplifies the task of a content developer adopting/extending the knowledge base to suit his preferences and fine tuning the system after the conversion.

We can illustrate the feasibility of this idea by implementing such a converter. Such a converter takes input from the content in the PCML Format and develops the content in the intended CMS. It will organize the content in CMS such a way as if it was created by the content developer with the help of a teacher.

Converter for a particular CMS will help to speed up development of content in CMS.

Converter has been developed for Drupal (Open source CMS) [8] and Vasistha (in-house developed CMS of C-DAC, Mumbai) [9]. Drupal and Vasistha have different methods for storing content. Drupal uses MySQL as database for storing content. Vasistha uses flat files. They have different organizational structure for content as well.

Converter can in general, be divided into two functional components – creation of an intermediate object representation of PCML content and populating content in CMS by programs which takes intermediate object as input. The intermediate object is independent from content in PCML and content in CMS. Initialization of an intermediate object also includes the validation check (syntax checking and semantic checking) for content in PCML. The same intermediate object has been used with a set of unique classes (program) for specific CMS to populate content.

VI. CONCLUSION

We have described the initial design of a content markup language suitable for use by teachers of various disciplines, not requiring any significant computer knowledge. The language, built on an XML framework, uses tags from the everyday repertoire of teachers, making the created content pedagogically self explanatory and shortening the learning curve for teachers. We have experimented with some variety of content and found the language adequately expressive. We have also implemented converters from PCML to a couple of CMSs as a proof of concept and found the results good.

Further validation of the language by a wide community and wide range of subjects is being planned. It will also be available at <http://www.cdacmumbai.in/researchgroups/etu> for

feedback and comments. Generalization of the converter Framework, based on a wide study of CMSs is also in progress.

VII. ACKNOWLEDGMENT

We acknowledge support from the Open source Software Resource Centre (OSSRC) and also C-DAC Mumbai, (Formerly NCST) for encouraging this work.

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Macromedia Flash Graphic Design Possibilities

Alen Okanović, Dubravko Banić, Tina Ćorluka
Faculty of Graphic Arts
Getaldićeva 2
10000 Zagreb, Croatia

Abstract—Because of limited capabilities of media processing in Flash, visual and sound components of many Flash projects are modified in other appropriate applications such as Adobe Photoshop, Adobe Audition, Macromedia Freehand, etc. and Flash is used to compile those materials in the desired composition. The main idea of this work is to overcome standard uses of Flash and to present it as a tool for creating design solutions through many possibilities that ActionScript programming language offers. Main features of this kind of design are computer-generated shapes, colors and compositions based on random selection in a way that the designer does not entirely know the final solution until the program ends.

Creating that kind of design solution requires fundamental knowledge of Macromedia Flash tool, ActionScript code and structure of algorithm. Our work will present how to make simple but effective solutions using basic tools only.

INTRODUCTION

While searching the Web, it was perceived that abstract contents rarely appear. Reasons are obvious. Purpose of design is to carry out a message or a thought. It is not sufficient for something to look nice in order to attract designated users' attention. However, design development led to a stage where there are many different streams and styles making it hard to be a prominent and innovative designer. This paper presents a programming solution for fast and efficient creation of abstract images using any kind of shapes. Usage of such solution is not frequent but it exists as an option and sometimes it presents the best method. Computer creation does not stop with this example. There are many ways of upgrading and developing new programs for creating visually attractive images.

INTRODUCING FLASH APPLICATION

Macromedia Flash application offers many capabilities. From simple easy-to-do animations and presentations up to creation of complex, interactive Web applications. The main characteristic of this tool is the ability to consolidate, synchronize and control picture, sound, video and other electronic media including user friendly interaction. Apart of using "What You See Is What You Get" way of working, Flash has a special program language; ActionScript that extends working methods providing the user with many ways of expressing his creativity.

Basic Flash interface consists of stage, tools panel and additional options palette. Since Flash application has limited possibilities of editing contents on main area of interface (stage), visual part of the project is simply composed in desired composition with slight modifications if needed. Modifications are performed with tools set in special tool

panel. Tool panel includes all necessary working tools while palettes contain additional options. Palettes can be arranged in order to customize working interface according to our desires and needs.

It is necessary to use library for realization of certain design solutions because of interaction possibilities of ActionScript. There are other ways of making interactive solutions but they are far more difficult and complicated as well as limited. Library is a main part of Flash and its symbolical name means that all objects created and inserted in this application are stored in it. Library includes contents such as video, sound, vector and raster graphics. All of these objects belong to a certain group depending on their types and have names within library, than the names through which they are accessed with ActionScript. Simple object modifications are enabled. There are additional organization options within the library that can, when optimally used, simplify large and comprehensive projects. Possibility of using library in all sorts of different projects is a great advantage. For example, some former work saved in library can simply be inserted in a new project without any multiplications or resetting the old data. For purposes of this paper, library is used to save an object that can then be used for computer created compositions made with ActionScript programming language.

INTRODUCTION TO ACTIONSCRIPT

ActionScript is a programming language that is a part of Flash application. This programming language offers many possibilities and each one of them is used to create more diversity in Flash content and interactivity with user. During Flash application development, ActionScript was adjusted for users that have never worked with any programming language and despite their lack of knowledge, they can create simple scripts. That was achieved with two working modes. The first one is the Normal mode in which scripts are created with a simple mouse click, fulfilling certain parameters for commands. The second one is the Expert mode in which entire code is hand written and requires certain ActionScript knowledge level just as the understanding of fundamental algorithms.

This is the list of basic ActionScript commands and properties that are used in work:

```
onLoad
function(){}
for(){}
attachMovie(idName, newName, depth);
setProperty("target", property, value/expression);
_x
_y
_xscale
_yscale
```

```

_alpha
_rotation
random();

```

1. *onLoad* – event handler in ActionScript programming language that must be connected to an object. It is also important to define function that will be executed when this event handler is invoked. In following example, variable *x* is defined when an object appears in animation:

```

movieClip.onLoad = function () {
    var x = 1;
}

```

2. *function(){}* – it is used for code optimization because it is possible to define many other commands for object inside this function. In this paper, it is used to execute commands such as object upload and to change its properties.

3. *for(){}* – presents program loop that executes defined commands until the condition becomes true. This loop is ideal for loading different information in arrays but in this work it is used to load objects from the library on stage and to change their properties.

4. *attachMovie(idName, newName, depth)* – every computer-generated image creation starts with this command. Some different methods are not mentioned in this work. Depending on certain parameters this command uploads specified or random object from the library on stage in position (0, 0). For successful execution of this command, it is necessary to specify which object will be uploaded from the library (*idName*), new name of uploaded object (*newName*) and its depth on stage (*depth*).

5. *setProperty ("target", property, value/expression)* – ActionScript command that is used to change objects' properties. Although it is not key command for creating computer-generated images, it gives many object manipulation possibilities and increases final solution variety.

6. *_x* presents *x* position of object's central point on stage, this value is relative.

7. *_y* presents *y* position of object's central point on stage, this value is relative.

8. *_xscale* presents object's horizontal width expressed in percentage.

9. *_yscale* presents object's horizontal width expressed in percentage.

10. *_alpha* presents objects' transparency and it is defined in interval between 0 and 100. If the value of this property is set to zero, object is invisible. If the value of this property is set to 100 object is completely visible.

11. *_rotation* presents objects' rotation angle in counter-clockwise direction, it is expressed in degrees.

12. *random ()* - often used function for creating abstract computer images. This function randomly picks one number in given interval. For example function *random (4)* will pick one out of the following numbers: 0, 1, 2, 3.

SIMPLE DESIGN CREATION

Construction procedure is divided into five examples. Each example is only a part of the final solution and it is possible to use it but the final result is optimized and ideal for use.

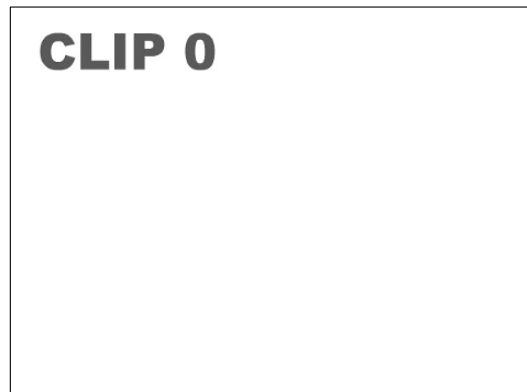
A. Example 1

```

_root.onLoad = function() {
attachMovie("mc", "movieClip", 0);
};

```

This simple example consisting of only two code lines holds the essence of random image generation using computer and its abilities. By starting the animation, in this case made of only one frame, written code is started as well. Analysis of this code is very simple. The *root* label represents the main timeline or animation flow and handler *onLoad* is attached on it. That means that this handler is going to be invoked at the beginning of the animation's main timeline. *attachMovie* command is defined inside the function and when *onLoad* handler is invoked function executes that command. That command does the following: it takes object named *mc0* from the library and places it on the stage in position (0, 0) because it is not specified; object is loaded on layer/depth number 0 that is defined with parameter inside *attachMovie* command; it gives loaded object new name that is defined by parameter inside *attachMovie* command.



Picture 1.

B. Example 2

```
_root.onLoad = function() {
attachMovie("mc", "movieClip", 0);
setProperty(movieClip, _x, 50);
setProperty(movieClip, _y, 150);
};
```

Second example is very similar to the previous one with addition of two code lines. *setProperty* command changes object properties such as stage position, height, width, etc. In this example, command *setProperty* is used two times in order to change object position in x and y direction. First *setProperty* command sets x position of *movieClip* object to value 50 while second one sets y position to value 150 of the same object. With start of animation, written script will conduct object loading from the library onto the stage in position (50, 150).

C. Example 3

```
_root.onLoad = function() {
attachMovie("mc", "movieClip", 0);
setProperty(movieClip, _x, 25);
setProperty(movieClip, _y, 75);
setProperty(movieClip, _xscale, 150);
setProperty(movieClip, _yscale, 20);
setProperty(movieClip, _alpha, 45);
setProperty(movieClip, _rotation, 150);
};
```

This example is extended version of second example. More *setProperty* commands are added and these commands change all properties of *movieClip* object. Besides x and y position on stage, its vertical width (*_yscale*), horizontal width (*_xscale*), transparency (*_alpha*) and rotation (*_rotation*) are changed as well.

D. Example 4

In previous examples, only one object from the library was uploaded on the stage. Exciting visual experience of created image is not achieved in such way. That image is simple and uninteresting. In order to create more interesting and more abstract picture numerous shapes and colors are needed. For that purpose few more objects are created in library that have similar names *mc1*, *mc2*, *mc3*, *mc4*, *mc5*, *mc6*, *mc7*, *mc8* and *mc9*. The idea is to load these objects on stage using only ActionScript commands upon animation start. Following previous examples *attachMovie* command is written for each object in the library.

```
_root.onLoad = function() {
attachMovie("mc0", "movieClip0", 0);
attachMovie("mc1", "movieClip1", 1);
attachMovie("mc2", "movieClip2", 2);
attachMovie("mc3", "movieClip3", 3);
attachMovie("mc4", "movieClip4", 4);
attachMovie("mc5", "movieClip5", 5);
attachMovie("mc6", "movieClip6", 6);
attachMovie("mc7", "movieClip7", 7);
attachMovie("mc8", "movieClip8", 8);
attachMovie("mc9", "movieClip9", 9);
};
```

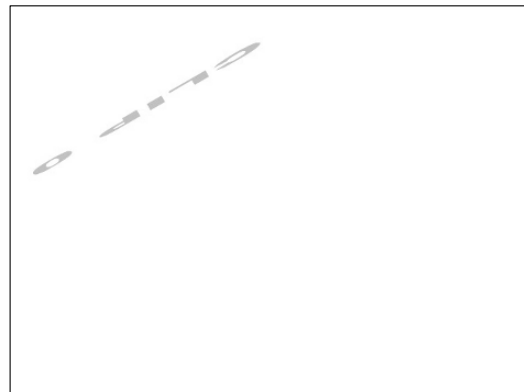
Picture 2.



At the beginning of the animation, this script will load ten objects from the library in the same position on stage. Such way of programming is correct; program will work but it consumes more time for writing and correcting eventual mistakes. There is an unwritten rule among programmers that insists on code optimization. In order to reduce writing procedure for each object specially and to achieve better script organization just as an easier review, simple *for* loop is used. This program in an optimized version looks like this:

```
_root.onLoad = function() {
for (var i=0; i<10; i++) {
attachMovie("mc"+i, "movieClip"+i, i);
}
};
```

In this example *for* loop is defined in the following way. Initial value of variable *i* is set to zero (*i=0*). During each run through the loop program will add 1 to variable *i* (*i=i+1* or reducibly written in ActionScript: *i++*) until variable *i* is less than 10 (*i<10*). When conditions are carried out, program leaves the loop. While analyzing the *i* variable it is important that its value is in the prime numbers' interval including zero (its value can be 0, 1, 2... etc.). The parameters within the command are somewhat different from the ones in the previous examples. Assuming that the *i* variable changes to



Picture 3.

$i=3$ at some point in time, the *attachMovie* command will, depending on the given variable considering the information of the first parameter ("mc"+3) that was taken from the library, take over the *mc3* object.

According to the information given by the second parameter ("movieClip"+3) it will be named *movieClip3*. The third parameter will give out the information that will set the object onto layer 3. As a result of the program loop, array of integers will be created from 0 to 9. Depending on the value of the variable i , command will take specified object from the library, it will name it ("movieClip"+ i), it will set it onto a certain layer (i) which is unique for each object.

For example, while passing through the loop for the first time the value of the i variable is zero. The *attachMovie* command takes the *mc0* object and sets it onto layer 0 naming it *movieClip0*. During the second loop pass the value of the i variable is 1 so the *movieClip* command takes the *mc1* object from the library, sets it onto layer 1 naming it *movieClip1*. In the last pass the value of the i variable is 9, *attachMovie* command sets the *mc9* object onto layer 9 naming it *movieClip9*. It is essential to set each object onto its own layer, if this is not done in that way and all of the objects are set onto one layer, new object (eg. *mc3*) will replace the one that was set before it (*mc2*) so when the program ends, there will be only one object (the last one – *mc9*). It is clear now why we use the specific naming of the library objects in this order; *mc0*, *mc1*, *mc2*, *mc3*, *mc4*, *mc5*, *mc6*, *mc7*, *mc8* and *mc9*. That way of using the for loop will add the library objects in a simple manner.

The advantage of this method of program writing is the ability to easily change and control the program. For example, if we want to insert 150 objects instead of 10. This is easily accomplished by changing the $i<10$ condition into $i<150$.

Similar to this example is changing the properties of each object on stage. That is why it is important to give a unique name (consisting of *movieClip* to each object) and unique number of defined variable i (eg. *movieClip43*). The following example shows the change of each object's transparency.

```
_root.onLoad = function() {
    for (var i=0; i<10; i++) {
        attachMovie("mc"+i, "movieClip"+i,
i);
        setProperty("movieClip"+i, _alpha, 25);
    }
};
```

The change principle is analogous to the code seen before. This script sets ten objects used from the library on stage while setting the property of each ones transparency to value $_alpha=25$ which means that the object is 25% visible. During the first loop pass, the value of i variable is zero. The *attachMovie* command takes the *mc0* object from the library, sets it to layer 0 on stage, naming it *movieClip0*. The second *setProperty* command will change the $_alpha$ property on the *movieClip0* object, setting it to 25. The next loop pass will take specific object from the library that is addressed with the

i variable, set it on stage and change its $_alpha$ property. The same procedure is used when changing the object's properties, x and y position, vertical and horizontal width as well as transparency and rotation.

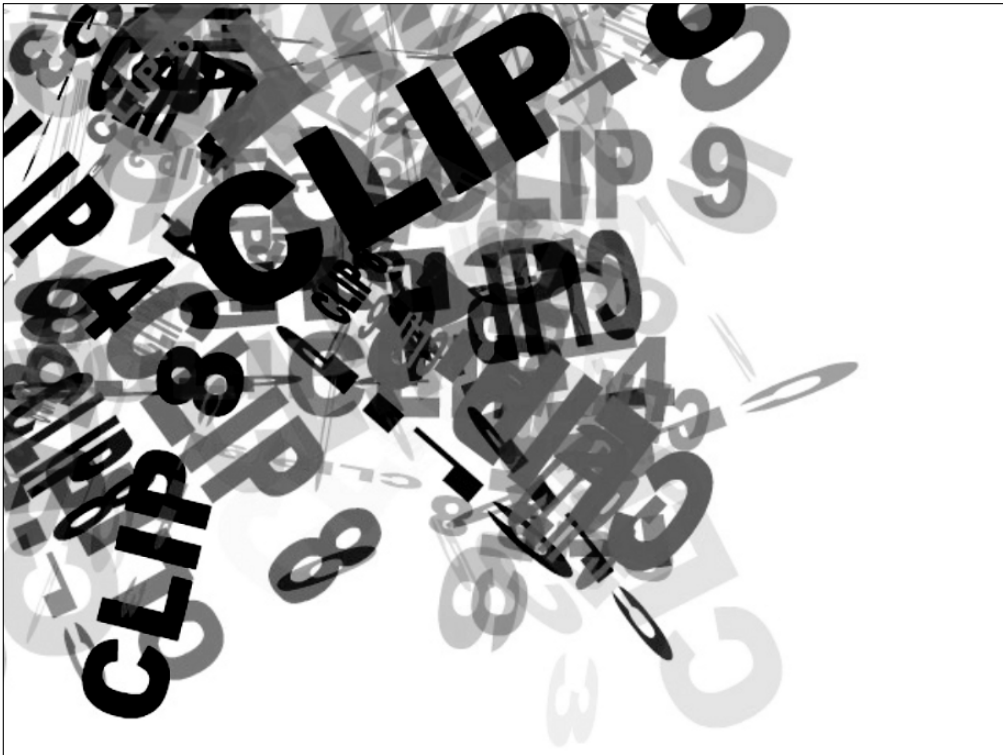
```
_root.onLoad = function() {
    for (var i=0; i<10; i++) {
        attachMovie("mc"+i, "movieClip"+i,
i);
        setProperty("movieClip"+i, _x, 25);
        setProperty("movieClip"+i, _y, 75);
        setProperty("movieClip"+i, _xscale, 150);
        setProperty("movieClip"+i, _yscale, 20);
        setProperty("movieClip"+i, _alpha, 45);
        setProperty("movieClip"+i, _rotation, 150);
    }
};
```

E. Example 5

After acquiring these basic principles of setting objects from library on stage and changing their properties, what follows next is adding the possibility of random object choice as well as random defining of certain property values. Idea was to write a program that is going to use method of random choices for picking some object from the library, placing it on stage and defining its position, width and height properties as well as rotation values. Command *random()* is used for creating such program. This command is ideal for solving this type of problem because it randomly picks integers in a given interval. There is a possibility to use command *Math.random()* that randomly chooses numbers in interval (0, 1) but it would be necessary to make additional modifications on it. It is important to mention that *random()* function is defined in every property in particular, because intervals of values that some properties can obtain vary considerably. For example transparency option can obtain values in interval [0, 100] while object positions x and y are defined by the stage size and can obtain values in interval [0, 2880] pixels. Rotation amount is expressed in degrees so the value interval of this property is [0, 360]. Implementing random function in certain places wanted goal is achieved in image generation sequence.

```
_root.onLoad = function() {
    for (var i=0; i<10; i++) {
        attachMovie("mc"+random(10),
"movieClip"+i, i);
        setProperty("movieClip"+i, _x, random(800));
        setProperty("movieClip"+i, _y, random(800));
        setProperty("movieClip"+i, _xscale, random(200));
        setProperty("movieClip"+i, _yscale, random(200));
        setProperty("movieClip"+i, _alpha, random(100));
        setProperty("movieClip"+i, _rotation, random(360));
    }
};
```

In this example *for* loop is not used for object picking from the library but for loading objects on specified depths of stage



Picture 5.

and for their naming. Object picking is conducted with random function that in this example has order to choose one number between 0 and 9 and according to that value to transfer specified object from library to the stage. For example, if random function is defined with $random(10)=5$ then the object "mc"+random (10), mc5 will be picked and loaded on stage. All object properties are changed with same command. For each object that is loaded on stage, all its properties are changed based on random number picking. Object position in x and y direction will be picked from the interval [0, 800], horizontal and vertical width from the interval [0, 200], transparency from the interval [0, 100] and rotation will be picked from the interval [0, 360]. It is possible to adjust value interval of random function to achieve specific value range. For example, in order to keep objects' transparency higher than 50% and to keep rotation angle between 50 and 89 degrees script is adjusted in following way:

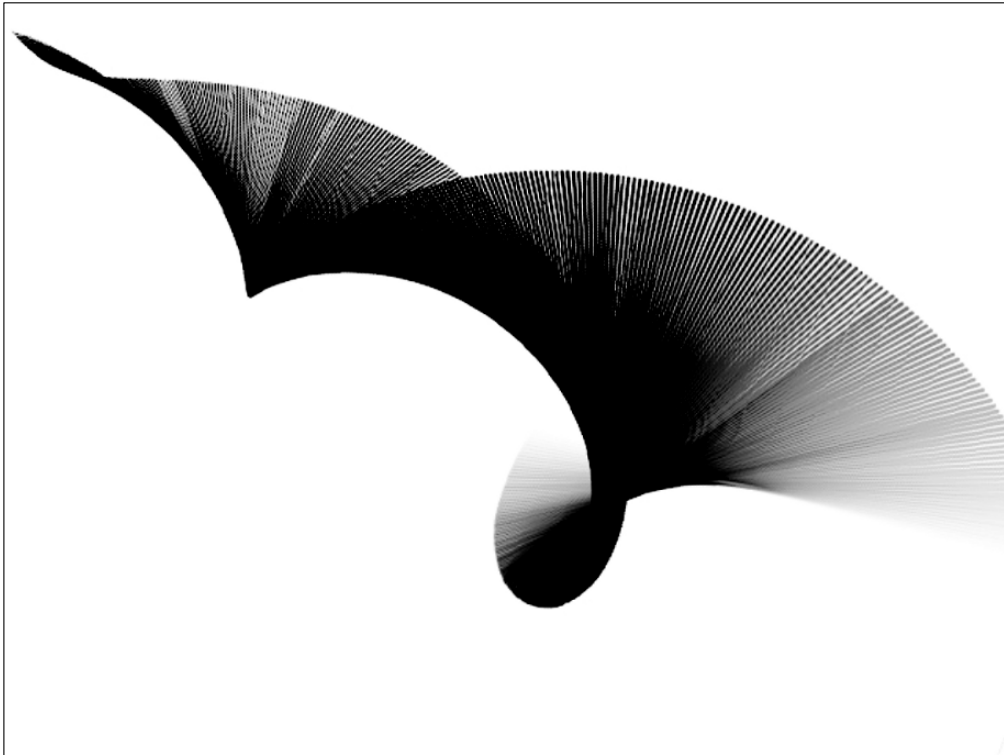
```
setProperty("movieClip"+i, _alpha, 50+random(50));
setProperty("movieClip"+i, _rotation,
50+random(40));
```

In first *setProperty* command, value interval that the object can accept is divided into two parts. First one is a fixed value

and to it randomly picked number is added from the second part of value interval so that the transparency property is always higher than 50%. Same model is used in second *setProperty* command. Minimal rotation angle is 50 degrees. To that value, a randomly picked number is added. This number is chosen from the special defined interval [0, 39] in order to keep minimal and maximal values in predefined range, that is [50, 89].

Surprise factor is created in picture creation by implementation of random function in the program. With each new program execution new composition is created using objects from the library. Chances that two completely identical pictures will be created are minimal and they depend on values of random value interval. It is also possible to run program repeatedly until user is content with generated image.

In previous examples, all object properties are hand written but with this script, image composition is completely computer-generated based on specific rules.



Picture 4.

CONCLUSION

This is simple example for creating composition using mentioned methods. It is possible to play with properties by implementing different functions when defining values of object properties. In such way, it is possible to make some order in the result and create less abstract picture using different mathematical functions. It is also possible to use golden section rule just like any other mathematical regularity or chaos. It is important to mention that even the predefined objects that are used in these examples could be computer-generated and the picture completely created using ActionScript.

With this program, we present one more option of designer's expression. Although these solutions usually do not provoke any emotion they still can look "good" with designer's vision and programming creativity. Sometimes it is even necessary to reach for such solution and Macromedia Flash application provides simple creation.

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New approaches for Linux-based Undergraduate Operating System Concepts Laboratories

Alessio Gaspar & Sarah Langevin

University of South Florida (USF),

3334 Winter Lake Rd, 33803, Lakeland, Florida (USA)

[alessio|sarah]@softice.lakeland.usf.edu

ABSTRACT

It is widely accepted that hands-on experience is key to helping students get a better grasp of the concepts, techniques and technologies introduced in lectures. The following quote, attributed to Confucius, embodies the underlying philosophy quite well; “I hear and I forget, I see and I remember, I do and I understand”. This paper discusses the design and implementation of a set of laboratories for an introductory undergraduate lecture in Operating Systems Concepts (OSC). More specifically, we focus on exploring how the Linux kernel can be made even more suitable as a vector from which to learn operating systems’ internals. To this end, we present a new pedagogical approach to Linux-based OSC laboratories which addresses issues stemming from Linux’s monolithic kernel architecture and its “real world” complexity. We also apply the lessons learned from educational operating systems (OS) and show how some of the assignments which are typically unsuitable for production-level OSes can be adapted to offer students the best of both world. This paper then describes how these ideas can be translated into a laboratory structure, which favors learning by scaffolding, and further develops this structure into a set of laboratories covering both “classical” and new topics in operating systems. The analysis of the technical and pedagogical features of these laboratories concludes this paper.

Keywords

Linux, Undergraduate Laboratories, Operating Systems, Kernel Programming, Loadable Kernel Modules LKM

I. INTRODUCTION

This paper is the result of recent developments in the SOFTICE project [1], a NSF-sponsored grant which aims at developing a clustering infrastructure to support and ease the adoption of Linux-based environments by higher education institutions regardless of the OS(es) already in use in the classroom. This effort also consists in developing laboratories which exploit the advantages of such an infrastructure and support undergraduate courses of the computing curricula such as Operating systems, System Administration and Networking. The focus of this paper will be solely on the pedagogy behind the operating systems laboratories, leaving applications to other laboratories and the underlying system administration infrastructure for future publications.

The development of laboratories for an undergraduate operating systems course is an exercise offering many degrees of freedom. Depending of the institution, the program’s objectives as well as the instructor’s teaching style, hands-on activities can encompass;

- Simulations of the algorithms studied in the lectures, often in a high level language such as Java [2]
- System programming aspects to learn how to interact with a kernel’s API before to “open the box” [3]
- Kernel internals aspects, using an educational OS (monolithic [4, 5] or micro-kernel architecture [6, 7])
- Kernel internals of a production-level OS; Linux is often used [8] in such scenario.

As a result of this plethora of available choices, major, and often heated, controversies exist. Among the strongest are those about the relevance of using the Linux kernel in undergraduate operating systems concepts courses (OSC). Such arguments question the soundness of using a complex production-level operating system vs. an educational one as well as the choice of an OS featuring a monolithic kernel architecture rather than a micro-kernel based one, etc. We believe that opposing such approaches is essential in improving the overall pedagogical quality in computing curricula and eliminating ill-conceived strategies. However, we also believe that it is necessary to devote some effort in making the best of any given approach for such a comparison to be sound. To this end, this paper will focus on the rationale behind our adoption of Linux to develop OSC laboratories and discuss how we addressed common issues associated with its complexity. We intend to share with the Computer Science Education (CSE) community how some of the Linux kernel’s innovative technical features can be easily leveraged to support and enhance significantly the pedagogy of a “first OS internals encounter”.

The next section will present our problem statement by identifying areas of improvement in existing related works. We will, for each of these items, discuss the various solutions we considered and present the pedagogical approach we selected to implement our laboratory series.

Section 3 will then discuss a general laboratory structure meant to introduce scaffolding in the students' learning experience. Section 4 will show how the above ideas and structure have been applied to the implementation of laboratories. Rather than detailing a single laboratory or providing a brief summary of all of them, we chose to group laboratories into categories and analyze the pedagogical methods and objectives used in each of them. This will allow us to conclude on how the ideas from the previous sections translate into solutions for both the pedagogy of teaching and the pedagogy of contents.

II. Pedagogical objectives

This section reviews issues encountered in Linux-based operating systems laboratories and discusses how we plan to address them.

A. From modifying code to using it

When exposing students to kernel programming, two types of activities are common whether they are using a "real world" or an "educational" kernel; (1) well-guided, almost "surgical", modifications to the code and (2) development of an entire OS component from scratch to illustrate or evaluate algorithms studied in the lectures. This section discusses the first type of exercise, leaving the other for section 2.4.

While it is definitively useful for students to learn to read, understand and modify other programmers' code, we question the idea of developing such skill in an undergraduate OSC course. When first confronted to kernel internals, students are generally provided with quite a serving of new concepts (concurrency alone is most challenging), algorithms and implementations. It seems that software engineering laboratories would be a much more appropriate venue to expose students to code reuse and analysis without making this exercise unnecessarily more complex by relocating it in kernel-space. Furthermore, this "guided code modification" approach disconnects students from what they learned to do in other user-space programming courses; e.g. develop their code in a problem-solving oriented way and reusing other programmers' code by learning to manipulate it through an API and associated data structures. It is reasonable to argue that aligning the OS laboratories' programming activities with what students already learned would allow them to leverage the benefits of previous courses and leverage an analogical learning approach. The question is to know whether this can be done while still fulfilling the objectives of an OSC course.

Our approach consists in favoring a "kernel developer" perspective in the laboratories by teaching students how to develop their own code in kernel-space rather than modifying the kernel itself directly. This allows students to

discover the kernel in terms of a new API and set of data structures with which they will have to interact. This switch of perspective is akin to adopting a skill-centered pedagogy rather than a fact-centered one; instead of learning *about the kernel code*, we aim for students to learn about *how this code is written*. This still exposes them to all the kernel-space constraints and techniques while illustrating, in a very pragmatic manner, the lecture's concepts such as kernel / user space separation. Students, by the time they take this course, should already be used to dealing with other programmers (or systems) in terms of APIs. We guide them through the initiation of a didactic dialog with the kernel, raising questions such as "how can I use your code? What are the rules to abide by when doing so? Is there anything about the implementation I should be aware of?". In order to leverage this collaborative logic and help students apply it to kernel programming, we rely on a technical feature of the Linux kernel: Loadable Kernel Modules (LKM).

B. Leveraging LKM technology

While the Linux kernel's architecture is clearly monolithic, it has been featuring a mechanism known as Loadable Kernel Modules for quite a while. However, maybe because of past controversies opposing it to micro-kernel designs, courses using the Linux kernel tend to follow a "monolithic pedagogy". The kernel code is made of components; each has strong interdependencies with one another thus calling for a minimal "bootstrapping" introduction to all of them before the students can start studying any particular one in details. Interestingly enough, devoting the first week(s) of a laboratory to a global overview to enable an individual analysis of components is not only common with complex, monolithic, production-level operating systems. Even when using educational kernels such as Minix, the components' interdependency calls for the same approach. The kernel code design itself is not at fault, and the rational has to be found in the very nature of an OS kernel. A. Tanenbaum explains [6] how an OS can be seen as more intricate to develop than an aircraft carrier. In the later, bathrooms plumbing can be designed and implemented independently of the radar subsystems. In the case of an OS kernel, memory management and file systems, to take only an obvious example, generally don't benefit of the same autonomy. While it is easy to write an operating system which boots and displays "hello world" on the screen [9], it is much harder to move on to the next logical step and have it do anything meaningful. Generally, almost all OS components need to be written, even if in a very simplified form, to ensure the system can work as a whole. These are obvious and compelling reasons indicating that enabling students' to tackle each OS component independently of the others is not an easy objective.

However, LKMs present us with an interesting alternative. Instead of understanding the kernel code by manipulating it

directly, we propose to have students write Loadable Kernel Modules (LKMs), which will be inserted dynamically at runtime inside of the kernel. This places students in the role of kernel-space code developers without requiring them to understand the whole kernel architecture and implementation before being able to interact with some specific kernel data structures or API. As they produce kernel code, students are still exposed to the implementation details, techniques and work conditions of a kernel developer. They simply can focus on a single isolated code unit of 50 lines or so, inside of their own LKM instead of having to peruse through various OS components' source code. As we will detail when delving into the laboratories themselves (section 4), this LKM-based approach enables quicker starts in the semester while also making the study of kernel components more autonomous than with a monolithic pedagogy. This, in turn, also enables the laboratories to be used as one-shot assignments thus widening the pedagogical impacts without intruding on existing curricula structures. This change of perspective also enables a task-driven pedagogy by which we decide on a set of objectives to be reached, and then introduce only the kernel APIs and data structures which are required to fulfill these objectives. This approach lends to a very natural presentation of the kernel in terms of functional units.

C. From using code to abusing it

So far, our students write LKMs instead of modifying the kernel code itself. Each lab will fix a task to be achieved by the LKM and introduce to students the kernel API and data structures they will have to manipulate in the kernel from within their LKM. What kind of task can be designed to support the course's pedagogical objectives? While the exact nature of these tasks will be detailed in section 4, we can already answer this question from a more general perspective; How can we motivate students to realize forays into the kernel from within a LKM?

LKMs are often used to load device drivers into running kernels [10]. On the other hand, root-kits [13] have also been intensively using LKMs as a way to alter the kernel of a compromised system. Alterations generally aim at providing backdoor access for the intruder while enabling him/her to perform arbitrary processes privileges escalation and information concealment (hiding rogue files and process on the target host). To achieve these tasks, root-kits load a LKM into the target kernel and interact with its API (replacing system calls by their own code) and data structures (unlinking concealed information, intercepting access to it, altering credentials). Besides being the expression of an unusually high potential for mischief from their author(s), root-kits are also evidence of a solid understanding of the kernel's internals. They are therefore good candidates for engaging students in learning about the kernel in a novel manner. Students seem globally receptive

to opportunities to learn about the inner workings of the security threats to which they are increasingly exposed. This desire to understand in depth the popular (and often misused) security jargon can also be a source of motivation by showing students the application of kernel knowledge to the implementation of classical root-kits features such as; files hiding, processes hiding, privileges escalation, system calls interception, etc. By "challenging" the OS in a hide and seek game, the students' critical thinking skills are taunted and our laboratories help them make the transition from "I understand what I read" to "I can use what I read" and finally to "I can critically revisit what I understand to generalize its use". In pedagogical terms, we foster the capability to generalize acquired knowledge and apply it in creative ways. In jargon terms, our students learn to hack at what they could have learned passively.

Another side-benefit of using root-kits as a source of inspiration is to introduce an applicative aspect of kernel programming. While graduate students are often innately curious about topics such as compilers and operating systems, undergraduates tend to be more concerned about direct applications. Nowadays, OS research and development isn't the only application of the knowledge gained in an OSC course; other applications exist such as device driver development, kernel tuning by system administrators, etc. Show casing these can help with motivation; it can also help in convincing students to experiment with kernels on their own. Most undergraduates feel a kernel can't be tampered with outside of the safe guidance of the OSC labs they just took.

D. What about writing from scratch

The above arguments reveal an interesting paradox. On the one hand, we encourage students to write LKMs from scratch and expand their existing programming skills to kernel-space. On the other hand, using Linux and its complex components seems to prevent them from being able to write a scheduler or a memory manager from scratch. In such an attempt, the need for proper locking (Linux is a preemptive kernel) as well as a need for even the simplest of replacement component to interact harmoniously with complex APIs, is enough to make this endeavor unlikely to be satisfactory from a pedagogical perspective. We are also further restrained by the fact that students are operating within the limits of a LKM rather than modifying the kernel code itself. This is where educational operating systems generally shine.

This scenario, once again, is focusing on a monolithic and complex kernel without leveraging its LKM-based modularity. Previous work showed the feasibility to embed specific kernel components (e.g. the scheduler) inside of a LKM [11] and "hot swap" them with the kernel ones. This technique has been used in the past to automatically evolve parameters for a scheduling algorithm implemented in a

LKM. Each set of parameter was evaluated by configuring then loading this LKM, thus replacing the original kernel’s scheduler temporarily, and then running a benchmark program. This framework, once adapted to the UML technology and recent kernel releases could allow for “write your own scheduler” laboratories that wouldn’t be hindered by the above-mentioned limitations.

What about components for which such an adaptation isn’t possible? As we already discussed, many different hands-on activities are used in undergraduate OSC laboratories. Among these, simulations of classical algorithms are used to illustrate their working without exposing students to kernel implementations. LKMs can also be used by students to implement a standalone memory manager or file system algorithms. These are not meant as a replacement for their kernel’s counterparts but rather as a way to provide user-space programs with new functionalities (e.g. a RAM disk, paged shared memory...). Linux can therefore provide support for the type of assignments educational operating systems are appreciated for while still providing the other opportunities discussed in this paper and, all along, developing students’ skills on an increasingly ubiquitous technology.

III. Labs implementation

Now that we laid the basis for a different approach, we can discuss its implementation. Contributions to the teaching community can take many forms [12]. We will start by focusing on the pedagogy of the teaching process by sketching out a structure common to all our labs which will support scaffolding learning. Then, we’ll discuss the pedagogy of the contents by reviewing the 3 categories of laboratories we have developed.

A. A scaffolding architecture

Each laboratory we developed is made of 4 sections; briefing, solved, exercises and projects. This backbone provides support for a progressively less and less “assisted” type of assignments.

The lecture provides students with the fundamental concepts, algorithms, and discusses implementation tradeoffs. The briefing section then bridges these newly acquired concepts with the Linux kernel implementation details. The implementation is used to reinforce the concepts but also to justify tradeoffs and choices which rely on technical or performance considerations. Once the relevant data structures and APIs are introduced to students, they are walked through a pre-solved example which exposes students to the briefing’s material in a more engaging manner. These can be “live” demonstrations by instructors or experimented done by students following the lab sheet instructions. The exercises section is then used to

confront students with increasingly more complex situations. The first exercises are meant as a drill, leading students to repeat hands-on what was just described. Progressively, their resolution involves analogical thinking based on previous lab material. Each exercise provides students with the building blocks they will need for the projects which will be used to test the students’ capability to generalize the applied knowledge to a more complex assignment. This structure isn’t enough to support scaffolding by itself. We only grade projects to evaluate the students while leaving exercises non-graded. This allows students to work in groups, seek external help and frees the instructor to help as needed without cheating or unfair grading concerns. Once the building blocks are in place, the help will be limited for the projects themselves. As the projects are built upon the exercises, most students’ questions can be answered by referring them to the appropriate exercise. Since most students will start by focusing on the graded part without devoting proper time to the exercises, it should be made clear that the projects aren’t feasible without the latter. Now that we have outlined the labs’ general structure, we can discuss them in more specific details. Rather than exploring them individually, we will review their pedagogical objectives.

B. Kernel developer training

To support the kernel developer perspective we discussed in the previous sections, three of our labs are geared toward introducing general kernel programming topics rather than guiding students through specific kernel components. The first one, “user-kernel communication”, illustrates the concept of user / kernel space separation by having students enable communication between user-space programs and their LKMs. From a technical perspective, we introduce useful techniques involving the PROC pseudo file system while making sure the implementation details underline the essential differences between kernel and user space (e.g. pointers from user space can’t be accessed directly within the kernel / LKM code and vice et versa). A second lab, devoted to synchronization issues, leads the students to implement, inside a LKM, solutions to classical IPC problems (e.g. producer-consumer, readers-writers). This exercise introduces the kernel synchronization API in a similar fashion than the Java, POSIX threads or sysV API are. By transposing these classical exercises into kernel space, we can show how our framework offers the same flexibility as user-space system programming assignments while still teaching our students about kernel programming. The last laboratory to fall in this category is devoted to the development of device drivers. It confronts students with an era of kernel development they are most likely to be exposed to while developing the topics of user / kernel space communication through the DEV file system. This laboratory constitutes a good wrap-up for the kernel development skills previously introduced.

C. Security flavors

Since our primary inspiration for these labs is root-kits, some of their features have been used to introduce students to specific kernel components. We focused on two distinct categories of security-related features; black and white hats. A first lab is revisiting the now classical exercise [8] consisting of replacing system calls. Instead of having students add their own system calls, we have them “hook” onto the existing ones by writing a LKM, which will intercept a given system call and replace it by a similar student-provided function. This lab is used to introduce students to the system calls implementation in the Linux kernel and as an early session to get them familiar with LKM programming. Two more labs have been designed following the “black hat” philosophy. They both deal with techniques meant to interfere with the kernel data structures related to file systems and process control blocks management in order to hide respectively disk data or executing processes from system tools. This provides an interesting and challenging way to introduce the kernel data structures used to manage processes. After altering credentials to get students used to the various *struct* and their fields, we start operating on the linkage of these structures into the main process queue. Altering the linkage of a given PCB without actually removing it from other lists such as the scheduler-related ones allows for a partial hiding of the process. This also provides us with an opportunity to explore the kernel’s linked list API which is by itself a rather awe-inspiring topping for students’ C programming skills. Last but not least, we also expose students to “white hat” techniques with a laboratory focused on file systems layouts. We took the FAT-32 file system as example and used forensics techniques [14] to guide students through the use of low-level tools to explore the file systems data structures as they are on disk. This laboratory offers a novel perspective on file systems topics which is complemented by introducing related kernel data structures in the “hiding files” lab described above.

D. Developing components from scratch

The last cluster of laboratories is devoted to providing students with the same opportunities they would have with simpler, smaller, educational operating systems while still further developing their kernel programming skills and knowledge about a production-level operating systems. This part of our work is still open for much more development; we will detail an already implemented laboratory and discuss other possibilities which we are currently investigating. Our first laboratory in this category is concerned with memory management. Students are required to add a handful of system calls to the regular kernel. These new system calls are empty shells which will be intercepted once their LKM is loaded, using the same techniques we already discussed in previous laboratories. The LKM will

provide the code to have these system calls implement, following several progressive steps, a paged shared memory system. Instead of modifying the Linux kernel virtual memory manager, which is generally a topic complex enough to be out of reach of an undergraduate course [15], we develop a memory manager embedded as an IPC mechanism. The LKM will allocate a page of kernel memory and manage it as a portion of physical RAM would be by the kernel MM. The allocated kernel memory will be chunked up in “pages” which will be managed through the new system calls by any user-space program (allocation, de-allocation, read, write). Each process registering to benefit from this LKM’s services will be assigned a virtual address space (and a page table) to which the kernel-allocated memory will be assigned as it is being used. Several processes will therefore be able to access pages of that kernel-allocated memory and use it as their own. As the assignment progresses, provisions to have some pages marked as shared will be added and, ultimately, another kernel-allocated memory bank will be used as a “swap” and allow students to test classical page replacement algorithms in this well-defined framework. Other possibilities we are currently investigating are focused on file systems and scheduling. It is possible to develop a LKM to manage a virtual RAM drive and provide access to a RAM-based file system of our own design to user-space programs. Such an assignment could complement both the memory management LKM described above and the device driver laboratory thus providing students with an opportunity to reinforce their acquired skills. While this new laboratory isn’t on our short term objectives, we already started work on investigating possibilities in scheduling. The situation for scheduling is slightly more complex but two projects could be used as base for a laboratory enabling students to investigate the Linux scheduler from a LKM perspective. The first possibility is based on the User Mode Linux (UML) virtual machines capabilities [16]. The SOFTICE project uses UML as an environment for students to work in all of our laboratories. We deliberately kept discussion of the underlying infrastructure for another publication but suffice is to say that UML offers opportunities in terms of hands-on exploration of Linux technologies that can benefit a significant range of courses in any computing curriculum. Recently, Jeff Dike proposed a patch to the Linux kernel which enables it to host an extra scheduler to which some processes can be assigned. We therefore can have students work on implementing a scheduler on their own and test it by re-assigning user-space processes to it instead of having them managed by the original kernel scheduler. A lot of efforts have been spent so far in getting this patch to compile inside a UML virtual machine. Problems encountered along this path have been reported to the UML community but haven’t yet been solved. We also investigated an alternative based on the work of [11] which used LKMs to replace in a “hot plugging” manner the

kernel's scheduler by a scheduler contained into a LKM. If this work can be transposed to newer kernels releases (2.6) it could constitute another opportunity for students to experiment with the scheduler by implementing their own inside a LKM without having to face the optimizations the existing code features.

IV. Conclusions

This paper discussed several new ideas for the implementation of OSC laboratories. We implemented them [1] by leveraging Linux kernel-side technologies to revisit classical topics and investigate new possibilities. Future work will focus on the following:

Battle field testing and evaluation; during the fall semester, several operating system and networking laboratories will be used as one-shot assignments in order to collect instructor and students feedback. During the year, regular laboratories will be scheduled in our IT department to support a more in-depth evaluation.

Dissemination and replication; our objective for this upcoming academic year is to implement automatic installers and packages. As a first step, we will focus on facilitating the installation and maintenance of our laboratories (virtual machines, disk images...). Then, we will expand this work to the installation and maintenance of the clustering architecture itself.

Extension to other courses; originally, the SOFTICE grant planned to develop laboratories for the OS and networking courses. We added recently Linux system administration laboratories and are working on applying our work to support in innovative ways other courses of the computing curriculum.

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The Case for Case Study assignments in Undergraduate Operating Systems Courses

Alessio Gaspar & Sarah Langevin
University of South Florida (USF),

3334 Winter Lake Rd, 33803, Lakeland, Florida (USA)

[alessio|sarah]@softice.lakeland.usf.edu

ABSTRACT

Undergraduate operating systems courses can benefit from a plethora of pedagogical activities and approaches; system-level programming, kernel programming, algorithms simulations, etc. This paper explores the benefits of assigning students a semester-long case study in such a course and discusses the lessons learned from doing so for the past 4 years. We then propose to revisit the core objectives of such an activity and suggest a generic structure which can easily be adapted to fit institutions, courses and instructors requirements. The proposed case study assignment offers a scaffolding-based guidance to students and combines a high technical level with a good diversity of topics while addressing the issues which are typical in such assignment.

Keywords

Operating systems, Instructional design, Undergraduate Operating Systems Course, case study, Computer Science curriculum, Information Technology curriculum

I. INTRODUCTION

This paper discusses the potential benefits of a case study assignment in undergraduate operating systems (OS) courses and suggests a generic design for such assignments. Let's start by defining the nature of the case study assignment we are discussing in this paper. Undergraduate operating systems courses, whether taught in Computer Science (CS) or Information Technology (IT) curricula, are generally the first opportunity for students to get an understanding of OS implementation and take their first peek "under the hood". As discussed in [6], while the material might be presented differently in each discipline, both share common objectives. Among them, enabling the students to take educated OS-related decisions in their professional environment based on technical knowledge is certainly an important one. A case study assignment is a good tool to both develop and evaluate such skills. Early in the semester, students agree with their instructor on a topic related to the course material then start researching and reading information about it. Their work is progressively narrowed down and is concluded by a "technical tutorial" which focuses on a specific aspect of the chosen topic. This tutorial is presented to the rest of the class during the week preceding the final examination.

Looking, using any search engine, for undergraduate OS courses making use of such assignment will return a plethora of results. This indicates that the idea is still popular with

instructors and students. Such an assignment is also at the core of most (if not all) graduate operating systems courses, thus hinting that its undergraduate counter part could play a central role in preparing students to graduate research activities or, in a professional setting, in preparing them to update their own knowledge as new technologies emerge. Despite these possibilities, very few publications have been exploring new strategies or reporting common pitfalls for such assignments ([5][6]). We believe that the graduate model is an appropriate guideline as to what we want our students to be prepared for. However, we also feel that we need to take into considerations other factors if we are to design a successful and rewarding undergraduate case study assignment.

For starters, both academic research and capability to update knowledge autonomously in a professional environment require similar "trunk" skills which could be developed by an appropriate case study assignment. It is important, in our opinion, to cater to the diversity of professional development options undergraduate students might select. Some will move on to a Master's, a Ph.D., some will join the workforce and pursue certifications. As a result of their undergraduate training, all options should remain opened to them.

Secondly, it is expected from graduate students to be able to be productive when they are involved in research. It is rarely appropriate to assume spontaneous emergence of skills in individuals, whether it is regarding teaching or research oriented activities. This observation led us to consider that while graduate courses can require students to already have autonomous research skills, we should work on providing them guidance to acquire them at the undergraduate level.

This paper introduces a case study assignment design resulting from 4 years of experience in teaching both CS and IT versions of the undergraduate OS course at USF. The next section presents our problem statement and identifies common practices and objectives associated with such assignments. We discuss lessons learned so far and review typical integration of case study assignments in the syllabus while stressing out the pedagogical benefits for the students. Section 3 details the design of our case study assignment, phase per phase, and discusses related pedagogical issues in reaching the above-mentioned objectives while avoiding common pitfalls. Section 4 discusses this design further and highlights the pedagogical mechanics at work. We conclude with a discussion of our future work.

II. Why case study assignments?

This section will provide background information to motivate the design of the case study assignment, as we are using it in our courses. We are going to review the pedagogical outcomes which are expected from such an activity, discuss the context in which the assignment was used at our institution and summarize the ~~errors made~~ lessons learned so far.

A. Typical Learning Outcomes

In the previous section, we sketched out the nature of the case study assignment this paper is discussing. Another way to define it is to look at the typical pedagogical outcomes.

- Technical writing skills & communication skills; Depending on the instructor, a case study assignment can result in a written report, an oral presentation supported by slides, or both. It can therefore be seen as an opportunity for students to apply what they have learned in technical writing and communication courses. This also means that this aspect of their work has to be graded with professional expectations.
- Research skills; Case study assignments are based on students researching information on a given topic for a good part of the semester. As such, they are expected to help students develop the capability to use library and internet resources to gather the needed information.
- Capability to synthesize information; the downside of the ease with which students can access information is the ease with which they can plagiarize it. However, with appropriate explicit warnings about the instructor's use of available automatic and by-hand plagiarism prevention tools, this is a trend that can be progressively discouraged.

Over the years, the case study assignments also revealed several side-benefits which, if not necessarily expected when the assignments were designed, aren't the least important motivation for using them in the OS courses:

- Autonomous technical knowledge updating skill; as we refined the assignments term after term, we progressively added focus on the necessity for students to continuously adapt to new technologies and report about them to their peers at a technical level. This perspective was much more successful at motivating IT students than the academic research one.
- Widen the course's horizons; since the very first usages of these assignments, we regularly had students whose professional interests built an interesting synergy with the assignment. To only mention an example, we had an IT student who worked with IBM mainframes and who investigated the internals of their OS as a case study. This helped us realize that case study can help students already in the workforce to apply the course material to improve their knowledge of the technologies which they are already familiar with. This type of work also proved to be

appreciated by the classmates who enjoyed sitting through presentations which expanded on the course material in ways which are not familiar to them (or even the instructor!). Each semester, at least some presentations contribute to open the horizons of the course. Having students share their results through an oral presentation rather than a written report also provides many more opportunities for in-class interactions which is critical for achieving this particular benefit of the assignment. This encouraged us to progressively give more and more emphasis on the oral presentation as a result of the case study rather than a written deliverable.

- Understand by explaining; most students will agree that having to converse technically with their peers is a commonly required skill. By having them tutor others in the topics they studied for a semester, we are trying to help them realize the difference between *explaining* and simply *regurgitating* material without being able to answer questions on it. The former requires an internalization of the knowledge without which students can often find themselves in rather embarrassing situations which might, in the long term, help them approach differently learning activities.

B. The way we walk

The next section will discuss the design of the assignments we have been using. When reading this section, we expect readers to think that more work (or less) should be required from the students. The key element is that this is, indeed, a relative notion. For this reason, we will start by discussing the context in which the case study assignments have been developed and how they are integrated with the other activities of the course.

The COP 4600 Operating Systems and COP 4610 IT Operating Systems courses are intended for undergraduate students respectively enrolled in the CS and IT programs at the University of South Florida. The course runs over 16 weeks including 3 sessions devoted to partial and final examinations, and 1 session for students' case study presentations. Students are also assigned programming assignments (several small ones or a big one broken down in independent "steps").

This syllabus has been significantly evolving in the past 4 years, and we are now about to offer a separate 3 hours weekly laboratory which will allow us to explore kernel programming techniques [1-4]. This should allow a reduction in the workload associated with programming assignments and increase the magnitude of the case study assignment instead. The results discussed in this paper are based on the original model in which, while important (30% of grade), the case study can't be too demanding on students.

C. Lessons learned so far

We taught the undergraduate OS course for either CS or IT audiences almost every semester for the past 4 years. This has been a great opportunity to test variants on this case study

assignment and explore new possibilities regularly, while finely tuning the most successful ideas. This also means that a great many of the ideas we explored weren't so good...

One of our first early errors has been to let students pick up their own topic within the first 3 weeks of the assignment. The only guidance, at that point, was that they had to select an OS of their choice and review its implementation by analogy with the techniques and algorithms discussed in the class. Retrospectively, it is now painfully apparent that (1) the nature of the topic (kernel implementations) was too constraining to address differences of interests in our students and (2) the topic was paradoxically not constraining enough in so far that students still had to choose a specific OS before they actually got to know anything about the discipline. This led to random picks in most cases which, in turn, led to relatively low levels of interest from the students. The only exceptions were students who wanted the course assignment to translate into an improved knowledge of their workplace technologies and accordingly selected their OS. This motivated us to start the assignment with a set of pre-defined topics. While we encouraged students to come up with their own, we also ensured that there would be enough sufficiently different topics to choose from to ensure students would get started in a timely fashion.

The issue of timing and keeping up the pace of work over the entire semester has also been a recurring problem from the very beginning. The worst scenario involved students taking half a semester to choose a topic and then coming back at each progress report with a generic, poorly defined and often too ambitious topic (e.g. Unix). In other cases, the workload required by other courses would simply encourage students to wait until the last minute and compact a semester's long worth of research into the couple of weeks preceding the oral presentation. These scenarios encouraged us to decompose the case study assignments into several phases each with a deliverable in order to ensure regular progress as well as break down the grading process. The later sections will discuss the exact design we adopted.

Another early lesson was to appreciate the impact that requiring a written technical report had on this assignment. During the first semester, students were required to provide both a written report and an oral presentation to the class. This approach was dropped in favor of a focus on the presentation and the questions or discussions following it. This allowed us to emphasize and refocus the workload on the actual research of information as well as the learning experience. Students were requested to delve into kernel code (when applicable for their topic) or to come up with their own tutorial code (when focusing at the API levels). This significantly helped students who were not comfortable with explaining and implementation but more interested in a case study which revolved around learning a new programming skill or technique. This also helped in reducing the plagiarism tendency (in most cases) in so far that the students were evaluated on their capability to explain in their own words the

topics at hand during the oral presentation but also expected to answer questions from their peers and instructors.

Lastly, the technical level of presentations has always been widely varying from student to student. This led us to incorporate clear expectations ruling out presentations solely based on historical, marketing or user-level considerations.

III. Redesigning the case study assignment

Now that we have clarified the nature of the assignment and the context in which it has been integrated, we can discuss in much more depth the version we are currently using and provide the rationale on the pedagogical choices behind it. The current assignment is broken down into the following 4 phases.

A. Phase 0: Topic selection

The case study assignment is generally started by a small presentation during a lecture which clarifies the general guidelines, what needs to be turned in and when. In addition to these contractual aspects, we also focus on providing students with an overview of the topics they can explore while encouraging them to go beyond these samples and come up with their own topic. As the assignment was progressively refined semester after semester, a "trunk" of topics emerged which consists in 3 main categories. So far this spectrum has proved to cover a wide range of different type of interest suitable for undergraduate students. These 3 categories have also enabled us to steer students away from topics which aren't technical enough for a senior level course. Let's review these 3 categories of topics and provide examples of the specific subjects offered as sample to students.

- Technologies: e.g. virtualization, SSI clustering. These topics generally appeal to students not necessarily comfortable with coding but interested in a higher level understanding of the implementation techniques and concepts.
- System programming APIs: e.g. Posix, Win32, SysV. These topics are for students interested in learning more about how to leverage their OS internals knowledge at the application development level.
- Kernel programming: e.g. Linux, Windows, educational OS. These topics are focused on kernel architectures and implementation and allow students to study a kernel of their choice over the course of the semester.

While there are many other ways to extend this list, it offers many degrees of freedom and provides enough examples to enable interested students to come up with their own topic. Categories I and II (technologies and system programming) are generally more popular (suitable?) for IT students while the category III (kernel programming) tends to be selected by CS majors.

In a small class this variety is generally enough to ensure that no two students will have the exact same topic. The

introduction will be similar but the rest of the development won't. In large classes, we'd recommend grouping students to work on a topic. We generally ask students to confirm their topics by email within a couple of weeks. This allows a time period in which they may explore several topics and ultimately make their decision.

B. Phase I: introduction

Once the students have "officially" selected a topic, the first 2 weeks are devoted to guiding them through an overview. This first step is supported by a written "topic guide" provided by the instructor which contains instructions and pointers to help the student discover the many facets of his/her topic. This first phase of the assignment will result in a 1000 words written overview report which highlights the followings:

Synopsis: students are expected to start their report by describing their topic and addressing general questions about it. Such questions vary for each family of topics.

In the technology category, students are expected to explain the fundamentals of their chosen technology and to discuss its main applications. For instance, students interested in SSI clustering are encouraged to differentiate such clusters from others (web farming, load balancing, high availability).

In the system programming category, these questions are more geared toward comparing the intents and composition of the API the student chose with the one(s) studied in class.

In the kernel programming category, students explore the various available kernels for their chosen OS. This is particularly interesting when dealing with open source kernels which are available for multiple platforms including embedded devices and networking appliances.

Terminology: for some topics it is important for students as well as for their audience during the presentation, to start on the right foot by defining the domain-specific terminology. An example would be the terminology used in SSI clusters or virtualization techniques which is essential to enable meaningful readings and discussions.

In the system and kernel programming categories, the terminology issue is less prominent and we expect students to spend more time on the other sections of this introduction.

Overview of possibilities for this case study; the purpose of this part of the introduction is to start students looking for a more specific subtopic inside of their topic of choice. This is done once they have acquired a basic understanding (terminology, synopsis) and will serve to guide them into the next step. To help them, we provide a list of possibilities and request them to review at least 4 in greater detail. The nature of the details varies depending on the topic family but we at least require students to provide the name of the technology / API tool / OS kernel, links to an "official" source of information about it where more information can be retrieved, a summary of the specifics of this particular item, typical uses

for it or areas of applications, capabilities, limitations and weaknesses.

For technology-related topics we enumerate the most interesting products available. We always try to favor open source projects or projects for which in-depth technical information is available in quantity and quality. In order to ensure that our students will learn something valuable and that technical information is readily available for their topic, we have to be particularly vigilant with "trendy" technologies. Most of these could make for interesting choices but information about them is often more of a marketing or rumor nature than technical. For each technology the students chooses to survey, (s)he will have to present it from the perspective of its potential and limitations, its favored domain of application and differentiate it clearly from other technologies.

In the case of system programming, the overview is focused on the tools and features made available by the chosen API. Again, we provide guidance in the form of a list of the components of the API which might be relevant for students to study. Particular attention is devoted to identify topics which can be learned by leveraging analogies with the course. Common suggestions include processes / threads / fibers manipulation and synchronization issues. Second to these comes the range of IPC mechanisms offered by the chosen API (JMS for Java, mailslots for win32 and messages queues for SysV). The main objective is to ensure students understand all that their chosen API can do for them before to select a specific subset to study in more depth.

The kernel programming category is differently structured. The overview is similar regardless of the chosen OS as we request students to provide a diagram of their chosen kernel's architecture. This diagram needs to highlight the components, their inter-dependencies and the exact nature of these dependencies. This is generally more time consuming than the introductory work required of other topics.

After 2 weeks, students email their introductory reports to their instructor who posts them in a dedicated forum thread on the course's blackboard site. This constitutes the official start of their personal blog (as a forum thread) on their case study and will be further used in the upcoming phases. At this point, everyone is capable to see which topics have been chosen and to read up on them according to their personal interests. Before the presentations, students will be invited to read these short introductions to prepare themselves to ask questions during their classmates' presentations.

C. Phase II: Bibliography

After the previous introductory phase, students should be aware of the possibilities offered by their topic. During the next phase of the case study, which is scheduled to last 3 to 4 weeks, they choose one of the four overviewed sub-topics and research it in much more depth. This phase is concluded with students emailing their instructor an annotated bibliography.

Their objective is for the students to find references which will help them in writing their technical tutorial. In order to help them navigate through this phase, we require them to use their forum thread to post, at least once a week, “blog-like” entries summing up their readings, providing references, and discussing its relevance (or non-relevance).

This phase defines a timeline for a critical part of the case study. It also enables the instructor to see, through the blog entries, how the students are working and provide appropriate feedback to correct their practices and guide them.

- Timing: are the posts regular and meaningful? Is a 2 week period summarized by a single post reading “worked on references, nothing useful yet”? It is important to teach students how to work, and it is too often still a necessity even at a senior undergraduate level. From the teaching perspective, these blobs help ensuring that the students will be rewarded for working regularly. From the grading perspective, students are instructed early that the regularity, quantity and quality of their postings will participate to their final grade in this phase.
- Technical level: once again, by guiding students through their chosen topics and ensuring they read appropriately-leveled references, we can steer them away from “shallow” presentations which can be written without having gained a real understanding of the topic at hand. This pushes students to focus on actually expanding their knowledge and sharing it in a meaningful way with their peers. The outcome is proportionally more satisfying for the students themselves.
- This allows the instructor to validate the students’ sources of information and steer them away from the google-only trend. This is also an opportunity to build their research skills by simply instructing them about the tools available (citeseer, library data bases ...). This can be also the occasion to teach them to be more critical about their information sources.

After the 3-4 week period, the annotated bibliographies are collected by email by the instructor and posted in the student’s thread for all to peruse through.

D. Phase III: Technical Tutorial

The last 3-4 weeks of this assignment are devoted to using the information collected during phase II to prepare a technical tutorial presentation. Once again, its exact content depends on the family of topics initially selected by the student.

For technology-type topics the focus is for students to provide an overview of selected system administration aspects (What is Xen exactly? What makes it work?), and then focusing on the technology implementation itself. For SSI clustering, the process migration technique and how it handles IPC mechanisms are essential aspects that need to be addressed by the student. For virtualization techniques, emulation or paravirtualization are the mechanisms which need to be paid

particular attention to. In order to tighten further the analogies with the lecture, the student is also invited to think about the impact on scheduling and system call implementation from the guest and host OS perspectives.

In the case of system programming, students are invited to provide an overview of the various data structures and functions which are part of the chosen sub-API. This part is accompanied by small code samples illustrating their usage and concluded by a complete code example illustrating the capabilities of the API. Students are required to write the code on their own without “borrowing” from IPC problem implementations downloaded from the web. The design of this code is expected to represent the main effort in this phase and will allow the instructor to evaluate the student’s understanding of the API.

When dealing with kernel programming topics, the students are expected to provide an explanation of the data structures and algorithms used in the kernel component they chose. This will be completed by a relevant kernel code segment walkthrough when dealing with open source projects. In the case of closed source commercial OS, the students are guided to compare their information with other OS kernels (such as the ones discussed in class) and discuss performance issues on the basis of published benchmarking results. Depending on the program the students belong to (CS / IT) or their personal preferences, some work can be devoted to link performance issues with a review of kernel parameters which impact them. This is particularly relevant to system administration inclined students who might have to finely tune systems for maximal performance.

The final result is a 15-20 minute presentation followed by a questions and discussion session.

IV. Discussion

A. 3 parts assignment

In many assignments, the instructors can only evaluate the final outcome and, at that point, any feedback is rather “punitive” for the student grade rather than instructive. This observation encouraged us to separate “instruction” from “evaluation” in some courses [1-4]. In this case study, many opportunities are offered to the instructor to observe the students’ progress.

We feel that it is necessary to correlate the object which is graded with the expected learning outcomes. For instance, if we only intend to grade our students’ capability to present the case study, intermediary information is superfluous. But, if we intend to grade their research methodology, blog-like entries are invaluable tools in providing insights into what the student is doing right or wrong.

Initially, the idea of decomposing the assignment in consecutive phases was inspired by the web quest [9] assignments. As part of our work with the USF Lakeland

Faculty Technology Integration Institute (FTII) group, we reviewed web quest assignments and evaluated how they could be adapted to senior level course. While web quests are successful in many fields, we felt they needed to be modified in order to fulfill the objectives associated with a senior-level college course. To this intent, we put some effort into articulating our case study assignment in various steps, inspired by web quests contract, and provide students with an improved guidance throughout the process itself. The resulting 3 phases follow the learn-expand-teach model discussed in [6].

B. *Introducing Scaffolding*

One of the main reasons we diverted from the web quest model is that we felt it offered almost too much guidance for a senior undergraduate course. Our main objective is to prepare our students for academic research or professional knowledge continuation. To achieve this objective, the necessary skills need to be introduced progressively throughout the curriculum. At the operating system course level, the idea is to apply a scaffolding approach by which we progressively reduce the amount of guidance provided to the students as the semester progresses. Phase I is heavily loaded with pointers and keywords the students can use to find their landmarks. It is also used to ensure students have a solid terminology to be used when doing their readings. Phase II is meant to provide students with assistance as they find their own sources of information without actually providing them directly or indirectly with links as we did in phase I. Phase III is the most autonomous since students are relying on the foundations they built in the previous phases to articulate their own explanations and develop their own code examples.

C. *From reading to contributing*

Plagiarism is a big issue. Some students are ethically-challenged and others are “confused” about what is a case study and where is the line between simply repeating what they read as opposed to learning, expanding and teaching from it. When introducing the case study, these topics are discussed in class to clarify the situation before hand. In addition to this clarification effort, it also proved useful to switch the students’ perspective on this assignment from “only synthesizing information and explaining it” to “contributing to a community of learners” through their tutorials. We are considering contacting several open learning communities [10] to have our students contribute their technical tutorial to a wider audience. This should help motivate them to improve the quality of their contributions beyond the “just an assignment” level into something they are willing to have their name associated to on a web public forum.

D. *Future work*

One of our short term objectives is to further develop the usage of library data bases and physical resources by our students. Most IT / CS students are more than proficient in finding information on the web. However, they are often

favoring general purpose search engines over more appropriate tools. They are also often oblivious to the locally available paper-based information sources. As we present the assignment to students, we try to point them to locally available resources early in the semester in order to progressively replace the “google-only” reflex by a “to the book repository!” one. Achieving this goal also requires us to start educating students to critically evaluate the validity of their sources of information which is an aspect we plan to further develop in upcoming work with FTII colleagues.

We are also planning to further develop the self directed learning aspects of this type of assignment in the context of USF Lakeland’s FTII group. As of now, the entire exercise is still overly guided. We are seeking to replace this process with a more open learning contract. This approach is much more demanding on the instructor (especially in large classes) but is also much more rewarding from the student perspective, as it explicitly focuses on building work methodologies.

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Inexpensive, Scalable and Transparent Open Source Classroom Management for Linux-based Laboratories

Alessio Gaspar, Sarah Langevin, William D. Armitage
University of South Florida (USF),

3334 Winter Lake Rd, 33803, Lakeland, Florida (USA)

[alessio | sarah | armitage]@softice.lakeland.usf.edu

ABSTRACT

Many courses in the computing curricula (CS, IT...) can benefit from hands-on pedagogical activities in the form of laboratory components associated with the lectures. While the benefits of such hands-on learning sessions is agreed upon, some courses offer a non-trivial challenge to instructors (and sometime even institutions) interested in providing this kind of experience to their students. Operating systems, system administration and networking are all examples of laboratories for which students need root access to be able to experiment with the concepts and implementation studied in the lectures. With this constraint comes the need for a more flexible classroom management strategy. This paper explores how some open source virtualization and clustering technologies can be deployed to provide students, as well as instructors, with such an environment. We focus on providing solutions which can integrate transparently to any campus without involving significant changes to the classroom computers. This enables us to integrate Linux-based courseware even on campuses exclusively using proprietary software without actually requiring Linux to be installed in the classrooms. We also emphasize the scalability aspect by providing a highly cost-effective solution which can be easily scaled up as the number of students or the requirements of the course in terms of computational power increase.

Keywords

Operating systems, System Administration, Networking, Classroom Management, Undergraduate Laboratories, Linux, Open Source, Computer Science, Information Technology

I. INTRODUCTION

A. Problem Statement

Let us start by stating the nature of the problem we are addressing in this paper. The pedagogical benefits associated with a “learn by doing” strategy are rarely contested. Computing education research publications confirm the benefits of “active learning” over lecture-only settings. At the same time, certification programs have been progressively moving away from pen and paper forms to hands-on examinations (RHCE, CLP...). Despite this increasing recognition of the potential of hands-on teaching and the growing interest for pedagogical innovations supporting these approaches, instructors and oftentimes entire institutions find themselves unable to apply these philosophies to certain courses of the computing curricula. Examples of such courses

include Operating Systems Concepts [5,7,11,17], Linux System Administration [15], and Networking [7,14]. Common to all these courses is the constraint that students need to have privileged access to their operating systems in order to engage in meaningful experimentations. This constraint has tremendous implications for the stability of these systems and their security. To maintain these, the instructor or the system administrators are often put through a very strenuous routine.

B. Traditional Approaches

Early responses to such requirements were typically to dedicate entire computer rooms to given laboratories and to reinstall the systems after each batch of students was done working on them. Not only does such a solution place extreme demands on the support team but it is also inconvenient for students (no network access in these labs) and academic administrators (difficulties in scheduling the room for other courses). The next step was for institutions to alleviate the system administration overhead by allowing students to bring their own personal pluggable hard drives to turn any workstation into their own personal system. Institutions which were concerned by the security implications of this approach adopted solutions based on facilitating the complete reinstallation of entire classrooms from a centralized repository of disks images. Finally, over the past few years, the computing education community has showed a growing interest in virtual machine (VM) technologies and applied them to overcome these constraints [16,18]. As always, there is still room for improvement.

C. Proposed Contributions

Since the inception of the SOFTICE grant (3 years ago [1-4]), we have been pursuing slightly different objectives which we consider to be the natural “next step” for the above-mentioned evolution of classroom management techniques.

Remote VMs for increased transparency

Even the most flexible VM-based solutions still require many modifications to classroom workstations. In some cases, the use of VMs forces students to carry with them the disk images they are working with. This particular problem can be addressed with proprietary solutions, which further complicate the classroom workstations settings. As well, this requires investing a significant amount of time and funds for the

acquisition of licenses and hardware capable of supporting the heavy-duty / bloated frameworks being deployed [20]. Such problems can be easily addressed in a Linux environment by providing students with remote access to a server which will execute the virtual machines on their behalf. Using simple, freely available tools such as PUTTY and Xming, students are able to connect to our server in text or graphical mode and manipulate their virtual machines over the internet. This allows us to have students work from any workstation (or their laptops) on campus and even from their personal computer at home. Because the above mentioned tools (or equivalent) exist on every platform (Microsoft Windows, macOS, UNIX, Linux), our solution integrates into any campus regardless of the OS already deployed in the classroom.

Cluster instead of server for increased scalability

Besides remotely serving VMs anywhere and to any platform, our second innovation is to provide a scalable solution with respect to the number of students and the courses' computational requirements. Generally, an increase in enrollment figures is addressed by upgrading existing servers. Similarly, if a new course involves particularly demanding activities (e.g. kernel compilations) a new dedicated server is provisioned. These somewhat traditional "reflex" practices are ultimately counterproductive and go against industry consolidating practices. As the number of "dedicated" servers grows, data centers have to eventually invest in consolidating them into bigger servers or clusters. We advocate the use, from the start, of load balancing clusters composed of off the shelf computing nodes (even recycled classroom PCs). From the students' point of view, there is a unique server (the master node) for them to connect to and on which to run their virtual machines. As they login, their connection is redirected to an available node in order to balance the workload on all available hardware. From the system administrator's point of view, only the master node requires attention regardless of the number of nodes federated in the cluster. These computing nodes can even be diskless workstations to further reduce maintenance. As more students enroll or if a course's requirements evolve, more nodes can seamlessly be added without requiring system administration intervention.

D. Paper's organization

Now that the problem is stated and we have hinted at how we have addressed it, the next sections will cover the technologies that were used, the rationale behind their choice, the technical advantage which they provided, and their pedagogical impact.

II. Transparency through Virtualization

Our focus being on Linux technologies, we strove to provide a cost-effective, easy to administrate and easy to deploy solution to enable instructors at Windows-centric institutions to explore Linux-based pedagogical material without disrupting the hosting infrastructure. This entails using virtual machines

and ensuring they can be deployed and accessed transparently with respect to the existing technological landscape.

A. Overview

So far, very few publications in the computing education community have reported classroom management techniques based on remotely serving access to VMs from anywhere on campus and to any platform. The closest work we have found to date [20] illustrates how costly is the use of proprietary solutions, in terms of licensing fees and complexity of the deployed solution. This complexity often translates into pricy high-end hardware requirements for each single classroom workstation. It also illustrates how, once adopted, such solutions are controlling the choice of operating systems that can be used on the classroom workstations. On the other hand, the SOFTICE project is committed to the use of open source software to provide students with remotely accessible Linux virtual machines. As we have already discussed, this allows us to use lightweight and heterogeneous workstations to access our server.

Beyond the remote-access considerations, we are using a virtualization technology which is both Linux-centric and lightweight and therefore particularly efficient. We adopted the User Mode Linux (UML) project [6] after considering various open and closed source alternatives such as Bochs, Plex86, Xen and VMware. These now very popular alternatives were discarded primarily because they emulate hardware. For our purposes, we needed only to provide virtual Linux machines running on a Linux host. To achieve this objective, the UML approach provides a much more efficient technology based on system call interceptions. This reduces the memory and computational power requirements of our VMs and enables inexpensive hardware to support more student sessions. We have left open the Xen alternative should we decide to support Microsoft OS images on our system as well.

B. Choosing User Mode Linux (UML)

While UML's performance was decisive in its adoption, this technology also offers many other intrinsic advantages. First and foremost, UML is an open source technology. This guarantees its affordability, its availability, and its flexibility for other institutions willing to replicate, adapt, or extend the infrastructure we are developing. UML is a mature technology which has already been integrated in the 2.6.x Linux kernel source tree and has also been used by many web hosting and (virtual) server collocation firms. From a technical perspective, UML is a port of the Linux kernel to a new architecture. Unlike most ports, this one isn't about making the Linux kernel work on some new hardware. Instead, the objective is to be able to run a Linux kernel as a simple process on top of another Linux kernel. For this reason, UML is often referred to as a port of Linux onto itself, which makes it more efficient than hardware emulation solutions. Simply by recompiling the standard Linux kernel source tree for this new UML architecture, we can generate an executable which

constitutes the “guest” kernel that students will execute as their virtual machine. To complete the virtual system, regular files can be used as storage devices, formatted as a hard drive, and booted by the UML executable after they have been populated with any Linux distribution.

From the pedagogical perspective, building a UML VM is also a way to teach students about kernel internals and compilation procedures. While with other VMs we would need a separate development environment to produce kernels which would then have to be installed on virtual disk images, our approach allows us to build a VM from scratch. One compiles a kernel and then runs it directly from within students’ accounts without further installation work. This considerably streamlines the build process and allows students and instructor to devote more time to pedagogical endeavors.

In comparison to previously mentioned alternatives, UML also allows for optimized performance. Firstly, UML doesn’t emulate an entire x86 hardware architecture. Furthermore, UML allows a reduction in the amount of disk space occupied by virtual disk images. Traditional systems require each virtual machine to boot from its own disk image. When students are working on a lab, it isn’t uncommon for them to have to manage several of these images [20]. In the case of UML, the so-called COW files (Copy On Write) can be used to have a group of VMs boot off the same disk image. As students modify the virtual disk contents, the changes are stored in their home directories as a COW file. This approach is extremely space efficient and can be coupled with the usage of HOSTFS mounts in order to allow students to access their home directories on the master node from inside of their virtual machines. This facilitates the transfer of files between VMs as well as the sharing of common directory contents.

C. Pedagogical impact

So far, we have applied UML to the development of labs for operating system concepts (OSC, completed) [3,4], elementary Linux system administration (ELSA, in progress) and networking courses (NW, in progress). Both OSC and ELSA labs require students to work as root on a single virtual machine while being kept isolated from the hosting network, while the NW labs require students to work on a potentially large number of workstations, switches and routers implemented and organized into a virtual network, which itself must be isolated from the hosting network. We are now testing the ELSA labs [1] and are working on leveraging UML’s multicast networking capabilities to have all students’ VMs automatically join a “virtual network”. This network will also comprise a utility UML VM whose role will be to provide other UMLs with various utility services such as DHCP, email, web, software packages repository. This will allow us to put students (and their VMs) in realistic situations where they have to interface with another server without granting them internet access. If necessary, this “utility VM” will bridge, in a very controller manner, this virtual LAN with the hosting network. While the ELSA lab series has proved rather

interesting from the infrastructure point of view but “classic” from a pedagogical one, the OSC lab series allowed us to leverage our setting to produce innovative pedagogical approaches to Linux kernel programming. Our previous works [1-4] have already detailed these pedagogical aspects and the technical facets of UML they have led us to explore.

III. Scalability through Clustering

Providing remotely accessible VMs is the next natural step most institutions will take. However, we believe that such infrastructures can be further improved by implementing them on scalable hardware. This section details how we did it.

A. Overview

Another difference between SOFTICE and similarly intended projects is that we provide secure remote access to Linux VMs by centralizing, in a cluster, all necessary computing resources and then load-balancing their access from a single IP. Consequently, students can use simple tools (Xming and PUTTY) to access their accounts and recompile or run VMs. The cluster nodes are on a gigabit local area network and connected to the internet only through the “master node”. Given this architecture and these objectives, many clustering solutions exist from which to choose. These can be roughly categorized into three generations. The first generation (e.g. original Beowulf class clusters) is characterized by the need to deploy a complete OS on each cluster node. “Generation 1.5” was introduced to alleviate the burden associated with large cluster system administration and thus improve scalability. Clustering toolkits such as Warewulf allow a master node to provide a booting cluster node their kernel and disk images, thus eliminating the need to administrate these nodes. The master node becomes the only machine to need administration regardless of the number of cluster nodes dependent on it. The latter can even be easily interchangeable diskless systems. The most recent evolution is SSI (Single System Image) clustering. This relies on process migrations to enable an entire cluster to appear as a single computer. IPC mechanisms, address spaces and process are shared by all involved machines. All processes, regardless of the machine they started on, are seamlessly migrated to other nodes when their host becomes overloaded. This results in a constant workload balancing using all available hardware. Technologies like Mosix or Open Mosix have pioneered SSI clustering and have been improved upon by Open SSI and Scyld Beowulf. These combine SSI benefits with the centralized images management offered by Warewulf. This results in clusters which behave and can be administrated as a single Linux machine.

B. Why are we not using SSI ?

We first considered Mosix and Open Mosix as SSI solutions but discarded them due to their constraining kernel patch release policy whereby only a specific version is supported. This policy would have prevented us from using the latest kernel release in our teaching or the latest UML versions. We

then evaluated Open SSI which integrates SSI features along with LVS' network traffic load balancing capabilities and centralized image management. We implemented our first cluster prototype using 2.6.10 kernel's open SSI release. Unfortunately, as we started developing UML-based labs for our operating system course, we realized that having students work on a recent (2.6.x) kernel version on top of the open SSI 2.6.10 kernel was going to prove problematic. As of the time of these experiments (spring and summer, 2005), UML had serious problems operating on some specific host kernel versions. This included, quite expectedly, the only version supported by Open SSI. We contemplated merging by hand both kernel patches but this would have meant updating this single patch at every new UML or Open SSI release. At the time, UML development was very active in response to many bugs related to its integration to the 2.6.x kernel series. To help us in deciding, we benchmarked our freshly installed cluster on kernel compilation tasks. These experiments revealed that the gain did not justify the effort of maintaining a merged patch. SSI technologies are based on the fact that processes can be migrated from one node to the other on the basis of the cluster's workload distribution. In many cases, applications can be seamlessly migrated to an idle node as soon as the one they are running on becomes overloaded. However, Linux kernel compilation tasks are an exception to the rule as they typically spawn numerous short-lived processes, each operating on only one or a few files. In fact, these processes are so fast that the SSI load balancing algorithms do not migrate them. Therefore, if a student logs in to the master node, all of his/her compilations processes will most likely remain on this node. If many students do so simultaneously, the master node will be overloaded while the cluster nodes will sit idle. This led us to realize that in addition to process-level load balancing, we also could use SSH connection load balancing as a coarse grained way to load-balance student sessions which can't be handled by process migration alone. At that point, we had to revisit which features we really needed and how to obtain them:

1. Network load balancing of incoming SSH connections
2. Process migration
3. Centralized image cluster management

The next step was to find an alternative to Open SSI to achieve these goals; we selected Warewulf and LVS.

C. Choosing Warewulf and LVS

Let's start by introducing the technologies to be integrated:

To quote the Warewulf wiki (<http://warewulf-cluster.org/>): *“Warewulf is a Linux cluster solution that is scalable, flexible and easy to use.”* ... *“Warewulf is the first of its kind which elegantly solves many of the problems associated with administration and scalability.”* ... *“Warewulf facilitates the process of installing a cluster and long term administration. It does this by changing the administration paradigm to make all of the slave node file systems manageable from one point, and automate the distribution of the node file system during node*

boot” ... *“From the software administration perspective it does not make much difference if you are running 2 nodes or 500 nodes. The procedure is still the same, which is why Warewulf is scalable from the admins perspective.”*

The Linux Virtual Server (LVS) project started as a kernel patch (IPVS) which is now mainstream in the 2.6.x kernel series. Its role is to implement a kernel-space level 3 router capable of redirecting network traffic based on application layer information. As of today, LVS is a *de facto* standard for implementing web farms or high availability services.

Let's revisit the three features we are interested in implementing. LVS can load-balance incoming SSH logins among the nodes and is already integrated in stock 2.6.x kernels. The second feature, process migration, would require a SSI kernel patch on the host kernel. To date, no such patch has been integrated in the mainstream kernel series, thus potentially causing incompatibility problems with UML (cf. above). Dropping this feature might be acceptable insofar that it failed to prove itself suitable to kernel compilation tasks. The last objective, easy cluster management, is critical to facilitate adoption of our solution by institutions with limited manpower to devote to this task. Warewulf fulfilled this requirement without kernel modifications and therefore integrates with both UML and LVS. By combining LVS and Warewulf we obtain two of the three features we were seeking.

D. Pedagogical impact

The use of these clustering technologies does not have a direct pedagogical impact on the laboratories we developed. However, it facilitates the adoption of our solution due to the ease of administrating the entire cluster. We also believe, from a technical perspective, that hosting a variable number of VMs on an easily scalable hardware infrastructure (just add nodes) is a significant evolution. Adding nodes is a seamless operation which provides a flexible hardware structure without requiring heavy system administration interventions. This compares favorably to more traditional settings in which enrollment increases or the specific requirements of a new course generally cause the system administration team to waste time on ordering, installing and testing new servers which will eventually require even more time to update, upgrade and ultimately consolidate. Our approach makes it possible to completely abstract the virtual machines and virtual networks from any hardware limitations and requirements. As the required computational power increases, nodes can be seamlessly added. As nodes become obsolete they can be just as seamlessly replaced. The same cluster will still be used throughout without any significant administration burden.

IV. Network virtualization technologies

An important step beyond virtualization of individual Linux-based systems is the virtualization of complete networks, including accurate emulation of workstations, servers, routers

and switches. There are several commercial and open-source solutions that can be used alone or in conjunction with each other to achieve this result.

A. Overview

Many commercial virtualization products have made their debut during the past few years; products such as VMware (and, more recently, VMware Server) and Microsoft's Virtual PC and Virtual Server have greatly popularized virtualization, aiming primarily at production systems. In many cases, these are now available at no cost (but not open-source), but tend to be resource-hungry.

The introduction of UML-enabled virtualization as an aid to teaching networking courses is not very recent. In 2001 and 2003 respectively, plans to create a virtual network of UML workstations for educational use [21] and realization of the concept [22] were reported. This approach used a single server to support the virtual networks and was thus not particularly scalable. In 2004, [23] described setting up a virtual network lab using UML-based virtualization, and illustrated clearly that creation of such a network, while not technically challenging, was also not for the faint-hearted or beginning networking student.

A networking course should emphasize experimentation with networks – not learning how to set them up. We therefore searched for a “meta-virtualization” approach – software that would effectively virtualize the process of creating and using a virtual UML network. Two open-source packages – Netkit [24] and My Linux Network (MLN) [25] were found. We decided to use UML, as it seemed to provide a greater level of “meta-virtualization,” making the process quicker and more intuitive for students.

B. Specificities of MLN

MLN requires as input a simple yet powerful network description file. This file specifies the UML systems and switches to be implemented, together with details such as network addresses, system size, filesystem templates, and the like. Instructors can easily specify networks, and, with little effort, show students how to specify any networks they themselves wish to create. MLN uses this file to automatically create required scripts to start and stop UML-based virtual networks; MLN also enables the upgrade of a running network, although that is not anticipated to be of much use in a networking lab, but could be very useful in other applications. MLN can start UML systems using either Konsole or *screen* utility consoles, although we are investigating the use of other console emulation approaches.

Through the use of “templates” – effectively predefined Linux filesystems – maximally lightweight UML systems can be created for such functions as routing. Being standard Linux systems, any software that could be installed on a Linux system can be preinstalled on a MLN template and used to define virtual systems. One example of such software is Zebra [26], an open source TCP/IP routing package that operates in

a manner similar to Cisco's Internetworking Operating System (IOS).

Through appropriate use of these templates, servers and workstations with special-purpose software may be preconfigured and made available for student use.

MLN was also attractive to us in that it has been expanded to support Xen, a virtual machine monitor that supports virtualization of multiple operating systems; this will allow us to work in the direction of running other than purely Linux virtual networks.

C. Pedagogical impact

In the networking course, the ease of definition of MLN and UML-based virtual networks will allow students to concentrate on the operations of computer networks, rather than spending valuable study and contact time learning how to use a simulator or even how to use UML commands to create a virtual network. By the end of a networking course, students can be expected to be able to create their own, complex networks for course projects as they like.

As part of laboratory development, a *netutil* application has been developed that can standardize network input for certain lab exercises, making it significantly easier and less time-consuming for instructors to determine if a student has obtained the proper results and to assign an appropriate grade.

A full suite of networking labs is under development and testing of individual labs is commencing.

We are also working on developing an Advanced Linux System Administration (ALSA) laboratories series to complement the above-mentioned ELSA one. This component will require students to be able to create spontaneously a network of UML machines and will rely on MLN to provide them with an easy way to do so. Again, as in the case of the networking labs, the ability of MLN to rapidly create and run virtual networks using a student-friendly interface will maximize the pedagogical efficiency of this course.

V. Discussion & Future Work

The SOFTICE grant goal so far has been to produce an inexpensive, open source, scalable solutions for institutions and instructors interested in using introducing Linux in their curriculum. To further facilitate adoption, we focused on alleviating the system administration tasks while still providing the above-mentioned features. We also took into consideration the constraint of deploying such a solution on a campus committed to proprietary software without having to disrupt its functioning or require heavy assistance from a technical support team which might not have Linux proficient personnel.

Compared to similar intended projects, we have been striving to not only use virtual machines technologies but also remotely serve them from the start and do so using a scalable and very flexible hardware infrastructure. This allows for the

deployment of low cost, thin clients in the classroom or for a seamless integration on any chosen platform.

To date some problems have been overcome and others have been marked to be revisited as the involved technologies evolve. The two most significant are the difficulties for UML to boot a virtual machines whose disk image is on a NFS mounted partition and the difficulties involved in making an Open SSI host kernel run a guest UML kernel. As time allows, we will regularly revisit these issues to update our workarounds to reflect progresses made on these issues.

Where future application of this technology to other coursework is concerned, likely candidates are lab courses on information security and network security. Practical experimentation with these areas can easily lead to corruption of an attached host network. Using UML technologies, such hosting networks can be isolated from inadvertently harmful experiments on the virtual network, yet students can use that hosting network to remotely access the virtual network to perform experiments.

The project's wiki [1] hosts information on both the system administrative and pedagogical aspects of SOFTICE. We have documented and tested the procedures to install our infrastructure from scratch and made them available to support replication or adaptation efforts in the community.

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A general Framework and Booking System for Online Laboratories based on Open Source Technologies

De Vora Alexander
Carinthia University for Applied
Science
Europastrasse 4
A-9524 St. Magdalen/Villach
a.devora@cti.ac.at

Auer Michael E.
Carinthia University for Applied
Science
Europastrasse 4
A-9524 St. Magdalen/Villach
m.auer@cti.ac.at

Grout Ian
University of Limerick,
Department of Electronic and
Computer Engineering
National Technological Park,
Limerick, Ireland ian.grout@ul.ie

Abstract— This paper discusses the creation of a common Framework for Online Laboratories especially used in the field of e-Learning. Online Laboratories allow students to deepen their knowledge by doing experiments in practice by use of Online Laboratories. These Online Laboratories can be accessed over the Internet - thus allowing students to participate in laboratories whenever they want and from wherever they are. Currently available reservation Systems for Online Laboratories are central based systems - allowing booking and access to the Online Labs over only one central system. The past has shown that this implies one big disadvantage: If the reservation system is down for some reason, an Online Laboratory can not be booked or accessed any longer! This paper shows a new way of avoiding this big disadvantage by use of a distributed reservation system. Furthermore it will show how easy and efficient Online Laboratories can be offered within a Common Framework.

Index Terms— Remote Engineering, Online Reservation System, Booking System, Online Lab Grid, Online Lab Network, Open Source, TYPO3, Content Management System

I. INTRODUCTION

In some educational fields it is necessary to impart the student's practical experience and knowledge by help of experimental laboratories. To enable also students who attend lectures via internet the opportunity to do practical experiments, different institutions started to develop the so-called Online-Laboratories.

The modern university needs to extend lifelong learning opportunities to its students anytime and anyplace to be successful in the global educational marketplace[1]. The overall goal especially in the field of engineering education is, to prepare students to practice engineering and, in particular, to deal with natural forces and materials. Thus, from the earliest days of engineering education, instructional

laboratories have been an essential part of undergraduate programs[2]. In many countries, a trend may be observed towards an increased use of simulation which frequently replace physical experiments[3]. Home experimentation is a method specially designed for distance learning students to acquire introductory hands on experience and become familiar with real components[4, 5]. Many academic institutions offer web-based experimentation environments which support remotely operated experiments [6-8].

Online experiments can be found in the fields of electronics, psychology, informatics, technology and physics. A lecturer who wants to prepare an Online-course using Online-experiments is often faced with some problems:

- Where do I find an already existing Online-experiment that is consistent with my lecture, and which I can also integrate into my course?
- Am I allowed to use this Laboratory and if yes, who gives me the guarantee, that this Laboratory is available when I need it?
- Is there a possibility to book the laboratory?
- Where can I find additional information about this Laboratory?

A Network consisting of different Online-experiments also providing the possibility of booking Online-Labs in advance would help teachers to include Online-Labs in their own course offering. The fundamental idea of this work is to solve the above problems and to build-up a network consisting of Online-Laboratories around the world offering a range of functions including:

- Online Labs can be included in an easy and comfortable way into the Network and thus increasing the amount of different Online-experiments available within the Network
- Online Labs can be booked in advance

- This network will be available also for the public sector to satisfy their thirst for knowledge
- This network will offer a lot of information about Online-experiments
- The network provides news in the field of Engineering and Science

The output of this project is a Prototype-network, demonstrating Online-Labs with different types of technologies and different types of online experiments that can be easily accessed, booked and connected to this Online-Lab Network. All the work is based on Software which has been published under the GNU - general public license[9] to ensure that the costs will be as low as possible.

II. ONLINE LABORATORIES

Online Labs can be divided into Laboratories made up only of software simulations and Laboratories made up of real hardware equipment or a combination of them is also possible. Software-simulations are often used in the field of mathematics where students can get an idea of what is standing behind a formula. Software-simulations are particularly used in fields where the setup of hardware is either too expensive or the setup of a Laboratory is, for security reasons impossible. They help students to improve their knowledge and help them to realise what is going on in the “real” world.

A large amount of currently used software simulations are already web based and thus allowing learners to get access to these labs any time and from any place of the world.

Web based software simulations are so called “Virtual Labs” and differ from Remote Labs in that way, that they only use Software while “Remote Laboratories” are made up of real hardware equipment. In comparison to “Virtual Laboratories” Remote Laboratories allow the manipulation of real hardware which is often done by use of Java Applets. These Applets usually represent the equipments user interface and let the user get the feeling as actually sitting in front of the equipment.

III. CONTENT MANAGEMENT SYSTEM, TYPO3

Content Management Systems are systems which administrate website content in a simple and efficient way. Furthermore CMS allow us to expand a Website and to make sure that the same style is used within a whole Website. All changes and enhancements can also be managed by persons without having a deep knowledge in the subject of Internet programming. By use of a CMS user permissions and group permissions usually can be managed in a very comfortable way. User groups that are allowed to maintain the whole website and other user groups that are only allowed to update content within a specified section of a Website can be easily generated. A website that should get administrated from each place of the world from different persons at the same time will also include the demand to support different languages. This project makes use of the Web Content Management System TYPO3, which has also been published under the GNU-general public license.

Over the years, TYPO3 has grown and expanded rapidly by meeting the needs of clients and end users. Some of the world’s best programmers and consultancies are interested in the development of TYPO3 and have formed a strong community in response to that need. When ideas are initiated, they are openly discussed among the user groups and quickly integrated within the next version of the software. Since TYPO3 is modular and well written, it allows developers to quickly create their own extensions and share them through a central repository that can be accessed via the TYPO3 backend. Typo3 provides a framework for building someone’s own applications. The kickstarter extension allows it to extend the database with tables.

A. TYPO3 Usability

TYPO3 enables administrators in an easy way to create templates. These templates can be programmed in order to meet the (X)HTML requirements defined by the W3C. Different CMS have been evaluated but none of them is able to produce a whole website in this standard. Developing a web-application which fulfils these requirements matters that the Websites style is the same on each browser and the Websites functionality can be warranted for each type for browser, too. If there is a demand on new functionalities (and we have the demand on new functionalities) TYPO3 offers the Extension Wizard. The Extension Wizard allows the programming of modules to make sure that we can expand the functional range of the System.

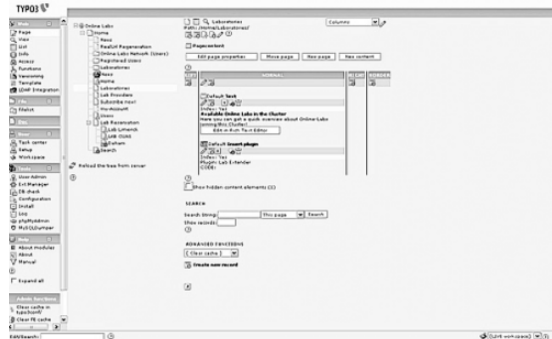


Fig. 1. TYPO3 Backend View (TYPO3 V4.01)

Since the Architecture of TYPO3 is based on **WAMP** (Windows, Apache, MySQL and PHP) or **LAMP** (Linux, Apache, MySQL and PHP) it has to be mentioned, that Typo3 is a browser-based CMS and runs on most common platforms like Windows, Mac OS X or Linux. The administration can be done by use of each standard web browser which means, that on the clients’ side no extra software is necessary. TYPO3 offers one of the most important features for this project: Each type of content can be restricted to certain users and groups! This feature made TYPO3 to the favourite for this project. No other Open Source Content Management System offers such good groupware functionalities.

IV. A SELF GROWING NETWORK FOR ONLINE LABS

After considering Online-Laboratories and Content Management Systems as separate entities, they now need to be connected together in order to build up an General Framework for a Module Based Distributed Online-Lab Network. Initially some design principles should be defined:

- The network has to run on different platforms.
- Lab Providers are running Lab Servers on different operating systems such as Microsoft Windows, Linux and Mac OSX.
- The amount of programming work as well as the need of specialized computer skills must be reduced to a minimum.
- The Software must be able to handle distributed communication - independent from Laboratory Software.
- In the Network a large number of Providers may be connected to a Web-Portal. So the network must be able to scale without major design changes to a large amount of simultaneous connected users and user requests.
- The whole design will make use of (where applicable) already existing tools in order to build the network with standards in Internet technologies.

A. The Structure of the Network

The network components can basically be divided into three main components:

1. The Web-Portal
2. The Group-Servers
3. The Communication Layers

The Webportal offers users the possibility to get information about Online Laboratories and furthermore it provides the feature for doing time reservation of Online Labs. The Web-Portals are working completely independent from the Group servers. These Group servers basically are the same as the global Web-Portals and are meant to be used as institutes Online Web-Portal. The COM-Layers are responsible for user authentication and also store the reservation details. This concept of storing the reservation data "external" is absolutely new in this field and offers several advantages.

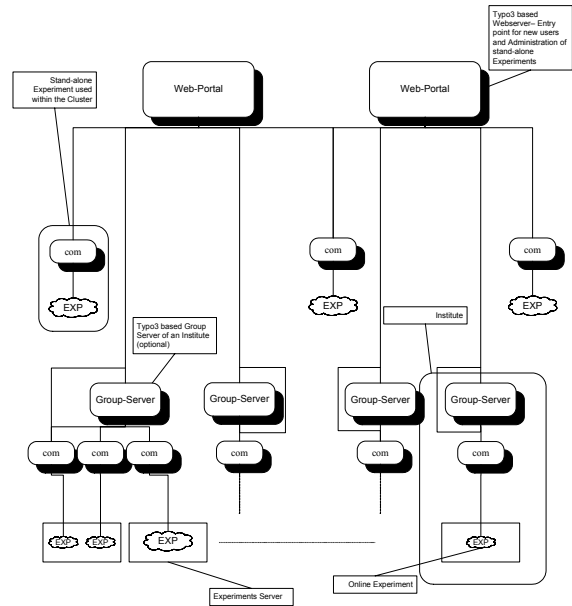


Fig. 2. Concept of the Laboratory Network

If the Webservice is down for some reason, either for booking an Online Lab or for accessing it, nobody is able to use a Laboratory. Since the concept of the Network also implies, that one Laboratory can be included in different Web-Portals, it can also be booked if one server is down - the user simply has to do the reservation on another webportal. Furthermore after a Reservation has been done there is no longer a need for the Web-Portal since all reservation data are stored in the COM-Layer which is located next to the Online Laboratory. This implies that the authentication process when accessing an Online Lab is done locally without the need for a Web-Portal. So the Web-Portal is "only" used for getting information, reading news and doing a reservation. Access control for the Labs is done independent from the Web-Portals - thus making the system on the one hand scalable and on the other hand quasi redundant.

For example, there could be a cluster in Austria, which is administrated by its "cluster leader" and there could also be another cluster in Ireland, which is administrated by the "cluster leader" of Ireland. Each of these clusters can contain several Groupservers. The Groupservers represent the Webportal of an Institute. As already mentioned these Groupservers are not necessary for joining the network, but they will give Lab-Providers the opportunity to use a CMS with the possibility of booking Online-Labs. To grant permission to a Lab Experiment itself, the COM-Layer is used. This COM-Layer has to hold all reservation data in order to grant access to the labs which are located behind it. Suppose an institution which wants to join the network with one or maybe some experiments. So the cluster leader has to create only a new Backend-user group in TYPO3 and the new institution is authorized to bring in its Laboratories into the

cluster. If they do not have any Laboratories, they are allowed to use Labs which are offered within the Network.

On the one hand the webportal represents the global entry point of the network while on the other hand the Webportal is necessary to administrate stand-alone experiments. For a better understanding it should be mentioned, that Online-Laboratories are made-up of Online-Experiments. For users the Webportal appears as “only” a Website, which offers users not only the ability to book Online-Laboratories - it also offers also a lot of other information about Online-experiments.

1) Typical Workflow – Setup Scenario

The Lab Provider gets a CD including a Setup-package. This Setup-package basically includes three installation-files:

- The Setup files for the Web-Portal
- The Setup files for a Group Server
- The Setup files for the COM-Layer

The Setup of the Web-Portal and the Group Server is nearly the same - they differ only in some pre-configurations of the Server and the backend-features available in TYPO3. During the install-process the user is asked to choose what he is going to install now: A Webportal, A Group-Server or a COM-Layer.

2) Bringing a Lab into the Network

After successful installation of the Setup package, the user can log in into the backend of TYPO3. To create a new Laboratory the Lab Provider is asked for relevant data concerning the Laboratory which are shown in *figure 3 Backend editing of Lab Information*.

Fig. 3. Backend editing of Lab Information

3) Booking an Online Lab

If a user is allowed to book a lab, he will be redirected to a Lab-Schedule. By help of colours, each field (each day) is indicating whether there have already been done some reservations on this day or not. On the right side of this page a so called “Info box” with further Information will appear.

After booking an online laboratory, a confirmation mail including the link to the Online-Laboratory, is sent to the user. Supposing that the reservation system is down for some reason, the link in the E-Mail still grants access to the Lab. In order to avoid unauthorised access to the Online Experiments this Link is encoded and only valid for a specific time.

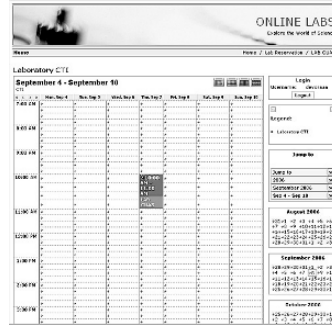


Fig. 4. Month-view of the Reservation Calendar with InfoBox

4) Security and LDAPS

Security plays an important role especially when dealing with personal users data. TYPO3 allows data to be transmitted in SSL-Secure Socket Layer mode. At this point it should be mentioned, that Typo3 also offers a comfortable way to import already existing userdata from an existing user-databases. Also these databases content can be transferred via a LDAP (Lightweight Directory Access Protocol)-Secure protocol. So it can be avoided, that userdata have to be administrated twice or be created new. The integration of this function will already be part of the install package, so that a Lab Provider which wants to import already existing user-data only has to follow some simple instructions.

V. CONCLUSIONS

The aim of this project was to develop a network for Online-Laboratories, which is easy to administrate, self-growing and which also offers the opportunity to book Online Labs in advance. Especially the concept and realisation of the reservation system has shown, that due to the avoidance of a central based reservation system the process for booking Online Labs has become significantly more failsafe.

The fundamental concept of this project is based on the idea to make use of already existing Software tools all published under the Open Source licence and to develop Software which

will be also published under this license. On the one hand this decision has been made in order to keep the costs for the network components as low as possible while on the other hand this should ensure that the progress of the network and its modules will have the chance to get enhanced in future. The use of TYPO3 as the basis for the Web-Portals provides a very comfortable way for offering Web Content, such as Science related content, news as well as RSS-feeds. Also TYPO3 offers a very easy administration of the Web-Portals, which is needed from the Administrators point of view.

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De Vora, A. received his M.Sc. (FH) degree (2002) with from the Carinthia University for Applied Science. From 2002 on he works as a Scientific Researcher in the field of E-Learning with the focus on Online Laboratories and Content Management Systems.

His research is related to Online Lab Networks and Resource Sharing Systems and is experienced in Internet Technologies.

In 2005 Alexander De Vora started in writing a Masters Thesis at the University of Limerick/Ireland with the title: A General Framework for a Module Based Distributed Online-Lab Network based on Open Source Technologies

He is member of the IEEE students section Austria and works in different international projects related to E-Learning Systems and Online Laboratories.

Michael E. Auer received his Ing. degree (1971) and his Ph.D. degree (1975) from the Dresden University of Technology.

In 1995 Michael Auer was appointed Professor of Electrical Engineering of the School of Electronics at Carinthia Tech Institute, Villach, Austria and works as visiting professor at the universities of Brasov (Romania) and Amman (Jordan). He is member of ACM, IEEE, VDE, IGIP, etc., author or co-author of more than 120 publications and leading member of numerous national and international organizations in the field of e-learning.

He is founder and chair of the annual International Conference "Interactive Computer aided Learning" (ICL, www.icl-conference.org) in Villach/Austria, chair of the steering committee of the annual International Conference "Remote Engineering and Virtual Instrumentation" (REV, www.rev-conference.org) and member of the Program Committees of several international conferences and workshops.

Furthermore he is editor-in-chief of the "International Journal of Online Engineering" (iJOE, www.i-joe.org) and the "International Journal of Emerging Technologies in Learning" (iJET, www.i-jet.org).

Ian Grout received his PhD degree in 1994 from Lancaster University, UK. Between 1995 and 1998 he worked as a lecturer within the Engineering Department at Lancaster University. In 1998, he joined the University of Limerick and is currently a lecturer within the Department of Electronic and Computer Engineering. His research interest areas include microelectronic circuit design, control systems applications, Design for Testability (Digital and Mixed-Signal), test technology and remote laboratory design.

Teaching Mathematics and Computer Programming Together

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

Abstract - Object-oriented computer programming and mathematical systems have commonality that may be used as a teaching tool: both operate with properties of and operations on abstract objects. A mathematical system is a triple {set_of_elements, axioms, operations}, while object-oriented programming structure is a triple {class, properties, methods}. It is suggested to use this commonality as a teaching tool with the goal of increasing students' understanding of abstract mathematical categories. Following this approach, students will learn writing mathematical problems as algorithms in pseudocode thus improving mathematical communication skills. In this paper, groups of natural and whole numbers, a ring of integer numbers, fields of rational and real numbers, and a well-known Nim game are considered as examples.

I. INTRODUCTION.

Successful teaching and learning mathematics comprises two indistinguishable components: mathematics connections to the real world and mastering internal logic of mathematics as a scientific discipline. Importance of the first component is out of question; for instance, [5] mentions development of applications skills in several rubrics. It is less noticed that understanding mathematics *per se*, as an abstract science underlying mathematics applications skills, is also of crucial importance.

An example is this. Most of my students in both high school and college experienced problems with understanding of the nature of real and complex numbers, though being able to perform operations over them. Talking to them, I realized they have never been taught that real numbers are actually sequences of rational numbers, that one real number has indefinitely many representing sequences, and, in particular, may be presented in different forms.

Here is another example. Students were unable to grasp fractions, vectors in plane, and complex numbers as just different interpretations of ordered pairs of integer or, correspondingly, real numbers equipped with different operations of addition and multiplication. This inability, in its turn, restricted their capability to surf easily between analytical and graphical interpretations of operations over these objects.

My students were also aware that polynomials are just functions of x or constitute left-hand side of equations. To provoke them thinking differently, I put in question, following

[1]: "...it is legitimate to inquire about the nature of the indeterminate x , and what does it mean to add x to <a number> ...or to multiply <a number> by x ? Should x^k be interpreted as representing $x \times x \times \dots \times x$ with k factors?... <Writing>... $(a+b)x = ax + bx$... why should we assume that x is distributive over addition? <An expression> $a_0 + a_1x + \dots + a_nx^n$ is a sum of elements of what?" Then I stressed, following [1] "...At times, we wish to consider a polynomial as a formal object with x representing <no numerical element> whatsoever". More general understanding of the nature of polynomials is practical, because even Associate's Degree in electrical or civil engineering requires taking a course in differential equations that, in turn, uses matrix exponents (and hence, matrix series and matrix polynomials), see, for example [9], for the degree requirements at Hostos Community College, CUNY.

Keeping all this in mind, I decided to seek for a way of teaching abstract mathematical topics using "tangible" tools. Object-oriented programming approach turned out to be a convenient one. Suggested approach to teaching and learning mathematics stresses that mathematics study objects and their properties, independently of the form of presentation of the objects.

In this paper the following two mathematical objects are considered: numbers and vectors. The difference is stressed between actual numeric and vector mathematical objects and just using the number-like or vector-like notation.

II. OBJECT-ORIENTED PROGRAMMING AND MATHEMATICAL SYSTEMS.

In this section I will briefly consider some very basic elements of object-oriented programming essential for this paper and map them onto the corresponding components of mathematical systems. Suggested approach paves the way for using abstract mathematical objects and classes of object-oriented programming interchangeably in a classroom. More detail regarding object-oriented programming may be found, for example, in [3] or [8], definitions and details pertaining to mathematical systems, in [4] or [10].

Object-oriented programming operates with classes and objects that possess properties and are subject to transformations called methods. (In this paper below,

“method” means a set of program statements that perform a certain task.) A class defines abstract characteristics of a thing in question, while object represents a particular instance of a class. Three main features of classes are essential for this paper: polymorphism, encapsulation, and inheritance. For the objectives of this paper, polymorphism may be considered as an abstraction from any actual class implementations, while encapsulation, as closure with regards to operations over the class methods. Inheritance, in this sense, is a possibility to extend a class to a wider one with more properties and methods, using the given class as a building block.

Similarly to that, a mathematical system contains a set of concepts and elements, a set of axioms related to the concepts and elements, and a set of operations over the elements of the system. A straightforward analogy between mathematical systems and classes may be set up at this point. Objects of a class may be considered as a set of the elements of a mathematical system, properties, as its axioms, and methods, as applicable operations. To make students more familiar with the suggested approach, I suggested them to consider natural numbers as a class, to point out its properties and methods, and then to expand it to the classes of whole, integer, rational, and real numbers. Table 1 represents expected outcomes: each class shown in its first column extends the class in a previous row. Students can see easily how feasible operations over different types of numbers are extended. Programming these classes in one of the object-oriented programming languages, like C++, C#, or Java, may serve as a challenging project for advanced students.

Suggested approach teaches students that mathematics may be considered as a science about properties of abstract objects rather than about objects themselves and thus, develops their critical thinking capabilities so needed in studying science and engineering.

The following should be stressed at this point. A number is a mathematical object representing an abstract notion of quantity. This object may appear in a variety of different forms. Thus, word-looking expressions as #ABCDEF and MCMXLVIII are actually numbers (the former is a number representing a color in a computer screen, the latter, a number 1948 in the Roman system.) Contrary to that, number-looking expressions like zip code 10451 or phone number 212-123-4567 are not numbers. To distinguish between them it may be pointed out that the ability to add objects serves as a boundary in this case.

III. TEACHING BINARY SYSTEM AND LOGICAL OPERATIONS VIA NIM GAME PROGRAMMING

In this section, an approach is suggested to teaching binary system, logical operations, and mathematical communications using a winning algorithm of a well-known Nim game. In this game, two players take in turn “stones” from piles until a player taking the last stone wins. Each player may take any number of stones from one pile, even the entire pile. Numbers of piles and stones in each pile are arbitrary.

To introduce Nim game in a classroom, any objects easily

TABLE 1.
Number classes, properties and methods.

Class	Properties	Methods
Natural numbers	Value (1,2,3,...)	Addition Multiplication Division with remainder Comparison
	Order	
Whole numbers	Value (0,1,2,3,...)	Addition Multiplication Division with remainder (except division by zero) Comparison
	Order	
Integer numbers	Value (...-2,-1,0,1,2,...)	Addition Subtraction Multiplication Division with remainder (except division by zero) Comparison
	Order	
	Sign (+ or - ; +0 = - 0)	
	Absolute value	
Rational numbers	Value ($\pm m/n$, where m and n are whole numbers, $n \neq 0$)	Addition Subtraction Multiplication Division Comparison
	Order	
	Sign (+ or - ; +0 = - 0)	
	Absolute value	
	Fractional presentation in minimal terms	
	Decimal presentation, including repeating case	
	Integer-number presentation in case $n=1$	
	Approximate value	
Real numbers	Order	Addition Subtraction Multiplication Division Taking a radical (only from non-negative numbers, if index is even) Comparison
	Sign (+ or - ; +0 = - 0)	
	Absolute value	
	Approximate value	
	Exact value, if possible, in terms of π , e , $\sqrt{\quad}$	

available, such as counting sticks, coins, and paperclips would suffice. I introduced Nim to the classroom in a “1 - 3 - 5” version, with three piles and one, three, and five objects in each pile, respectively. Students were instructed to play the game in groups, write down the moves, and explain briefly the intuitive reasoning for at least one of their moves. At the conclusion of the games, we went over the reasons for the moves and discussed which of them were right or wrong; see

[6] for detail. After that, a winning strategy of the game was introduced, [2]. It is this. To win, a player should write down the number of stones in each pile in the binary system, one under the other, and count the numbers of binary 1's in each binary place. If there is at least one column with an odd number of 1's, then the player wins. To win, he should leave the opponent in a position with an even number of 1's in each column. Otherwise, another player wins provided that he follows the same strategy: it may be proved that any move made in a position with all columns even makes at least one column odd, [2].

Example. Consider 1-3-5 Nim game. As $1_{10} = 1_2$, $3_{10} = 11_2$, and $5_{10} = 101_2$, the leftmost column is odd, so the first player wins. It is assumed for simplicity, that the second player always takes two stones from the largest pile or empties the first non-empty pile if no pile contains two or more stones. A corresponding sequence of moves is listed:

$$\begin{aligned} \begin{pmatrix} 1 \\ 3 \\ 5 \end{pmatrix}_{10} &= \begin{pmatrix} 001 \\ 011 \\ 101 \end{pmatrix}_2 \xrightarrow{\text{Player 1}} \begin{pmatrix} 001 \\ 011 \\ 010 \end{pmatrix}_2 = \begin{pmatrix} 1 \\ 3 \\ 2 \end{pmatrix}_{10} \xrightarrow{\text{Player 2}} \\ \begin{pmatrix} 1 \\ 1 \\ 2 \end{pmatrix}_{10} &= \begin{pmatrix} 001 \\ 001 \\ 010 \end{pmatrix}_2 \xrightarrow{\text{Player 1}} \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}_{10} = \begin{pmatrix} 001 \\ 001 \\ 000 \end{pmatrix}_2 \xrightarrow{\text{Player 2}} \\ \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}_{10} &= \begin{pmatrix} 000 \\ 001 \\ 000 \end{pmatrix}_2 \xrightarrow{\text{Player 1}} \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}_{10} = \begin{pmatrix} 000 \\ 000 \\ 000 \end{pmatrix}_2. \text{ Player 1 wins.} \end{aligned}$$

As one can see, after any move of the first player, all columns are even.

Consider now how the winning strategy may be implemented in terms of an object-oriented programming language. As our main objective here is presentation of the way of teaching mathematics, we use pseudocode to free ourselves from syntax, rules, and restrictions of a specific programming language, do not deal with a user interface, and follow [6] in the algorithm description.

Going through the program below, students learn integer and modulo 2 division, logical operation XOR (eXclusive OR), decimal-to-binary conversions, loops, arrays, using intermediate variables etc. We avoided using built-in standard methods of binary-to-decimal and number-to-string conversion for the sake of presenting more details. In the following description, the algorithm itself is given in bold, data structures, in italic. The rest of the text may be considered as comments.

The main method named **nimMove()** regards to a current move of the first player. Its arguments are: *Piles* - the integer number of piles, and *StonesByPile* - the integer array of stones located in each pile before a move. The output is *NewStonesByPile* - the integer array of stones located in each pile after the move.

The method implements an algorithm that uses two types of loops: a **for**-loop and a **while**-loop. Actually, these loops are equivalent, and it is just a question of convenience to use

either of them. Usually, a **for**-loop is used when the number of repetitions is known before the loop starts, and **while**-loop, when the end-of-loop condition is generated inside of the loop.

The algorithm of the **nimMove()** method forms an intermediate binary matrix *BinaryStonesByPiles*. Rows of the matrix correspond to piles, while columns, to the 0's and 1's in the binary representation of the numbers of stones in the corresponding piles.

Loop by piles (the outer **for**-loop):

Loop by number of stones in the current pile (inner **while**-loop):

Divide the number of stones modulo 2 to find the remainder, 0 or 1.

Starting with the rightmost available cell, begin by recording the remainder into it and proceed further with writing subsequent remainders in adjacent cells to the left.

Repeat the loop with the value of the quotient of integer-2 division.

Proceed while the integer division quotient does not equal to zero.

End-of inner loop.

End-of-outer-loop.

Example. Consider a Nim game with five piles containing 15, 12, 10, 7, and 6 stones, correspondingly. To generate the first row of the *BinaryStonesByPiles* matrix, we proceed as follows with “%” symbol standing for modulo division, and “/” symbol, for integer division: $15\%2=1, 15/2=7; 7\%2=1, 7/2=3; 3\%2=1, 3/2=1; 1\%2=1, 1/2=0$. At this point, the inner loop for the first pile is ended, because zero-quotient is achieved. The first row of the *BinaryStonesByPiles* is (1,1,1,1), as follows from the results of modulo-2 division. The next step of the outer loop deals with the next pile. Eventually, the following *BinaryStonesByPiles* matrix is produced for the given *StonesByPiles* decimal array:

$$\text{StonesByPile} = \begin{pmatrix} 15 \\ 12 \\ 10 \\ 7 \\ 6 \end{pmatrix}_{10} \quad \text{BinaryStonesByPiles} = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 \end{pmatrix}_2$$

In the binary matrix, the first row is $1111_2 = 15_{10}$, the second, $1100_2 = 12_{10}$, etc; its rows are produced using the algorithm shown above.

At the next step, the method generates an intermediate binary array *CurrentPosition* to determine whether the number of binary 1's in the columns of the binary matrix *BinaryStonesByPiles* is even or odd. To do this, the XOR (eXclusive OR) operation is applied: XOR(0,0)=0; XOR(0,1)=1; XOR(1,0)=1; XOR(1,1)=0. (It may be mentioned that XOR operation is frequently referred to as a Nim-sum.) The values in the cells of the *CurrentPosition* array contain the XOR-sums calculated for corresponding columns of the *BinaryStonesByPile* matrix. For the matrix given above we get *CurrentPosition* = (1, 0, 0, 0). This means that the

leftmost column contains an odd number of 1's, so that first player wins the game.

Consider the first move leading to win. In accordance with the winning strategy rule given above, the player should make all the columns even. To do this, he should choose any row that contains 1 in the leftmost odd column. In our case, he may choose either row 1, or row 2 or row 3. Assume that row 1 has been chosen. Its leftmost cell should be converted from 1 to 0, while the rest of the cells in that row should remain unchanged, because all the other columns are even. Doing so, the following output matrix *NewStonesByPile*, is formed:

$$NewStonesByPile = \begin{pmatrix} \mathbf{0} & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{pmatrix}_2 = \begin{pmatrix} 7 \\ 12 \\ 10 \\ 7 \\ 6 \end{pmatrix}_{10}$$

The updated value shows up in boldface in the binary matrix. Comparing the two arrays, *StonesByPile* and *NewStonesByPile*, we realize that the present move is this: "Take $15 - 7 = 8$ stones from the first pile".

The algorithm demonstrates that the winning strategy move may or may not be unique. Thus, in a position given above, instead of making changes to the first row, the player could change the second row from 12_{10} to $4_{10} = 0100_2$ to arrive at an even position. During a game, the method described above should be used repeatedly after each second player's response until the first player wins by taking the last stone. A class corresponding to Nim game is shown in Table 2.

TABLE 2.
Nim class.

Properties	
<i>NumberOfPiles</i>	Value: <i>Natural number</i>
<i>StonesByPiles</i>	Values: <i>Array of whole numbers</i>
<i>Result</i>	Values: <i>{Win, Loss, Continue}</i>
Method	
<i>nimMove()</i>	Algorithm of the method.

Web site [7] allows playing three-pile Nim game on the Internet. If initial position contains an odd binary column then the algorithm leads the first player to win; otherwise, it makes random moves with hope on the second player's mistake. The web site also presents an example of how a user interface of a real board game may be realized.

The following note is important for the goals of this paper. A part of an object representing Nim game is an array of non-negative numbers. The question arises, whether it is a vector. The answer is no, because such objects cannot be added to each other. The only operation over them is the transformation described above aimed at arriving at the winning position.

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Knowledge Representation of DC Electrical Circuits Analysis for E-Courses – From Basic Concepts to Long-Term Strategies

Amir Abdessemed¹, Jean-François Lebeau¹, André Mayers¹, Habib Hamam²

¹Department of Computer Science, University of Sherbrooke
2500 Boul. de l'Université, Sherbrooke, QC Canada

²Faculty of Engineering, University of Moncton, Moncton, NB Canada
amir.abdessemed@usherbrooke.ca

Abstract – This paper describes a work in progress which consists in representing knowledge related to the analysis of DC electrical circuits taught to electrical engineering undergraduate students. In this paper, emphasis is put on the explicit representation of resolution strategies which span covers several steps, or the entire resolution process. To that end, a domain-independent cognitive-computational knowledge representation model is used, specially adapted to handle the description of long-term strategies. The resulting modelled knowledge is taught through an intelligent tutoring system.

I. INTRODUCTION

Researchers of various specialties worked on the use of the computer for educational means since it became available to the public [1]. There are many categories of computer-aided-learning software, the most popular being the Web Based Homeworks [1], and the most powerful being the Intelligent Tutoring Systems (ITS). The latter are generally robust software, able to adapt their behaviour to the level of the learner and his preferences, and predict his actions.

If adaptation and prediction are important aspects of ITS, the research at the ASTUS lab is motivated by the assumption that they are not sufficient to achieve an effective improvement in teaching methods, and that a close representation of humans' way of storing information and reasoning is necessary when dealing with human learners. More than that, adaptation and prediction can greatly benefit from a cognitive way of representing knowledge. Some works are based on the same assumption [2]. Thanks to that, a number of cognitive ITS are available or in development.

An ideal system trying to simulate human reasoning would be able to do so in several independent domains. The aim of the ASTUS project is to be able to represent semantic and procedural knowledge of various domains using a generic model. This knowledge is to be interpreted and taught by a reusable system.

Currently, methods of representing domain-related concepts and their hierarchy exist, as do methods to interpret actions on an ITS interface as steps in a problem resolution process. An example of such representation, the ASTUS knowledge representation model (KRM) is briefly described in the following sections. What such representations lack is a

description of long-term reasoning and resolution strategies. To give a simple example, if regular knowledge representation may define Ohm's law, the correct way to apply it, the immediate changes in the problem and the immediate benefit from it, there is no explicit depiction on the reason to choose the application of this law over another method when seeking a current value, when dealing with a particular problem, at a particular step. The reason could be a strategy adopted at the beginning of the resolution process, or somewhere between the beginning and the step of actually applying the law.

The domain of DC electrical circuits' analysis was chosen because of its adequate and variable abstractness as first domain to test strategy representation upon. If problems involving simple circuits are used, simple and even trivial strategies are necessary to represent and apply. As the KRM gains robustness and expressiveness, more complex strategies can be depicted, such as performing modifications on a circuit to make it equivalent to a school-case.

The remainder of the paper is organized as follows. First, we briefly introduce our previous work. Next, our current way of modeling semantic and procedural knowledge is described; followed by a description of our first attempt to represent strategic and long-term knowledge. After that, we give a brief description on how the current knowledge database is used inside our ITS, and how adding strategic knowledge is improving it. Finally, we conclude by announcing future work.

II. PREVIOUS WORK

The ACT-R knowledge model [2, 3] and Miacé [4], a human cognitive architecture were the foundation of our current works. Both aim to introduce cognitive theories in intelligent tutoring systems.

Until lately, our primary works were related to establishing and testing a formalism for representing semantic and procedural knowledge, and to design a highly reusable internal structure of the future ITS. The first domain chosen to test the KRM was boolean reduction problem solving [5, 6, 7]. The knowledge related was clear, and the concepts to represent reasonably few. The fact is that one main strategy was implicitly defined by the way of representing the knowledge. It seemed that there was no need to teach this, or any other

strategy at the time. Final tests of the model have shown that even if satisfactory results were obtained, explicit representation and teaching of reduction strategies could be of benefit, like allowing feedbacks on a sequence of resolution steps, or the whole problem solving process.

Similarly, it was possible to achieve a solution in problems related to DNA identification [8] thanks to an implicitly defined strategy. Working on this domain allowed detecting several cognitive inconsistencies and description limitations in the previous version of the formalism, but also showed that introducing more abstract reasoning and strategies could lead to better solutions. As real-life DNA identification requires expensive means, teaching identification optimization techniques along with the identification itself might be of some benefit. However, the gain was judged insufficient considering the additional work required, as acceptable solutions were reached anyway.

Since our primary goal was to ensure the reusability of our KRM, we chose another domain where long-term strategies are crucial for the problem resolution process, and where teaching these strategies is part of teaching the domain itself. The domain of electrical analysis was chosen as it is more abstract and complex. It offers more challenge to validate our representation model, and test our strategy-related modifications. Also, the mathematical aspect of the domain, e.g. the use of variables and equations, can easily be reused in other domains of physics.

III. SEMANTIC AND PROCEDURAL KNOWLEDGE

As for real-life education, the teaching of a domain by an ITS implies a clear definition of the concepts related and the relations between them. In the case of the ASTUS project, the defining structure must also allow basic semantic reasoning and classification. Examples of that are automatically identifying a resistor as being an element (abstraction), or implying that current "I" in the branch B is the one to consider when applying Ohm's law on a resistor being on this branch (equivalent to visual identification). Several methods of representing semantic knowledge exist, such as frames, predicate logics and semantic networks. Their expressivity and the reasoning capabilities they allow greatly vary, as do their primary purposes. For the ASTUS project, the Web Ontology Language (OWL) [5] is used to ensure a Description Logics (DL) [5] based representation. The common constraints that we deal with, mainly identification and classification problems are due to the limitation of the theory's expressivity and the absence of entirely compatible reasoning engines. See section VI for possible improvements. Some of the defined concepts, their hierarchy and the relations between them are shown on Table I.

According to cognitive theories [9], we assume that every user intention is a goal; and every action to fulfill this goal is a procedure.

TABLE I
HIERARCHY OF CONCEPTS

Concept	Is-a	Relations
Concept	/	/
Node	Concept	IsPartOfBranch(Branch)
Physical object	Concept	HasVoltage(Voltage)
Branch	Physical object	HasElement(Element) HasNode(Node) IsPartOfNet(Net)
Element	Physical object	IsOnBranch(Branch)
Resistor	Element	HasResistanceValue(ResistanceValue) IsParallelWith(Resistor) IsSerialWith(Resistor)
Value	Concept	AssignedNumber(Number)
Number	Concept	[a real number is embedded]
Vector	Concept	PointsTowardsNode(Node)
VValue	Value	IsVValueOfVoltage(Voltage)
RValue	Value	IsRValueOfVoltage(Resistor)
Voltage	Vector	HasVoltageValue(VValue)

A goal, by definition, is semantic knowledge, but it is used to build procedural knowledge in combination with procedures. If the semantic knowledge can be expressed explicitly, procedural knowledge is inferred by a succession of actions achieved automatically. In our KRM, procedures are subdivided in two main categories: primitive procedures and complex procedures. The first correspond to learner actions on the ITS interface that cannot be a source of a domain error. Complex procedures can be done by sequences of actions, which satisfy scripts of goals. A problem solving process is therefore a succession of intentions (goals) and sets of actions (procedures) motivated by them. The main goal represents the whole resolution of the problem, and each primitive procedure is a learner's action on the ITS interface. Goals and procedures are interlinked by argument passing. These arguments named cognitions represent instances of concepts mentally handled by the learner.

Fig. 1 shows the interface of the ITS prototype when in circuit analysis teaching mode. The interface and the problems given are simple, as the focus of the current work is on the KRM itself and the use of it to give feedback. The Tables II and III list respectively some of the goals and procedures that are involved in solving the problem shown on the figure. The goals and procedures, although obeying to the generic KRM formalism, are named using domain related terms. The formalism is based on domain-independent goal/procedure patterns, such as sequence, conditional and iteration structures.

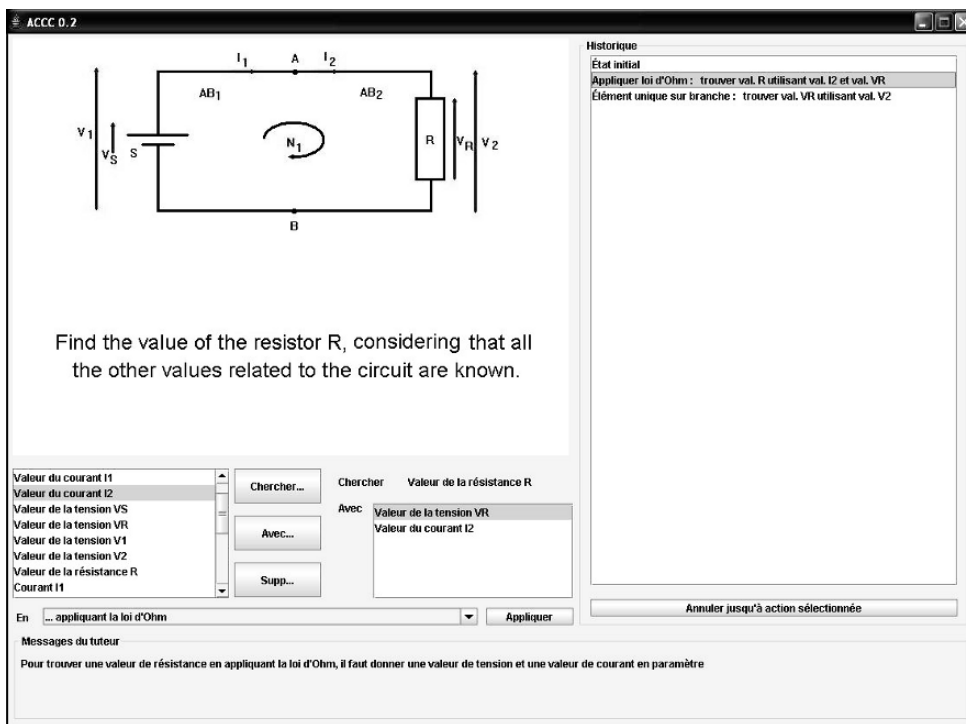


Fig. 1. A simple problem and the beginning of the solving process.

TABLE II
EIXAMPLES OF GOALS

Goal	Procedures needed to fulfill the goal
FindValue (Value: x)	<ul style="list-style-type: none"> • Check if (Value: x) is known • If (Value: x) known, ReadValue¹ (Value: x) • If (Value: x) unknown : DealWithUnknownValue (Value: x)
CalculateValue (RValue: x)	ApplyOhmsLawToCalculateResistanceValue (RValue: x)
CalculateValue (VValue: x)	CalculateAVoltageValueKnowingLocation (VValue: x)
CalculateVoltageOfPhysicalElement (VValue: x, Resistor: y)	ApplyOhmsLawToCalculateVoltageValue (VValue: x) <ul style="list-style-type: none"> • SubstituteVBranchToVElementIfOneElementOnBranch (VValue: x) • RetractVBranchFromVREmainingElements (VValue: x)

Another aim of the ASTUS project was to create an authoring tool [10] for domain experts to represent semantic and procedural knowledge related to various domains for teaching purposes, in a graphical user-friendly way. Fig. 2 shows a step of knowledge base creation using the tool.

TABLE III
EIXAMPLES OF PROCEDURES

Procedure	Goals created at the execution of the procedure
DealWithUnknownValue (Value: x)	CalculateValue (RValue:x) or CalculateValue (VValue:x) or CalculateValue (IValue:x) <i>[The type of value is implicitly identified thanks to the semantic reasoner.]</i>
ApplyOhmsLawToCalculateResistanceValue (RValue: x)	Semi-sequence: <ul style="list-style-type: none"> - (Resistor: y) = IdentifyResistorKnowingItsValue (X: RValue) - (Branch: z) = IdentifyBranchKnowingElement (Element: y) - (Current: a) = IdentifyCurrentKnowingBranch (Branch: z) - (Branch: z) = IdentifyValueOfVector (Vector: a) - (Value: b) = FindValue (Value: b) a. [after I], (Voltage: c) = IdentifyVoltageOfPhysicalObject (Phys: y) b. (Value: d) = IdentifyValueOfVector (Vector: c) c. (Value: d) = FindValue (Value: d) Last. ApplyOhmsLawToCalculateResistanceValuesReady (x: RValue, b: IValue, d: UValue)

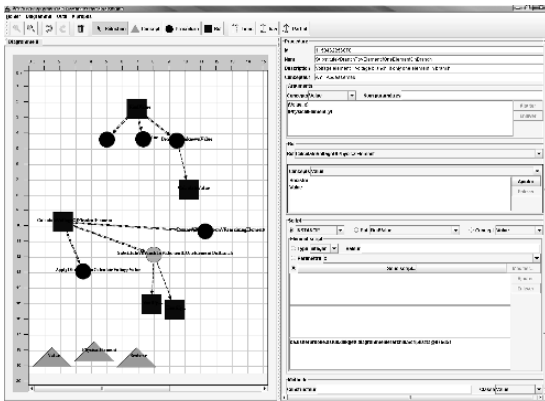


Fig. 2. Editing procedural knowledge using the authoring tool.

IV. REPRESENTING STRATEGIES

As mentioned earlier, our previous version the KRM and the models of the currently available ITS are limited in the ability of representing abstract thinking, involving strategies and cognitively expressive long term planning. Several popular ITS use a production rule system to select the most adequate procedure in a given situation, relying on fixed coefficients to represent rules priority. As for the previous KRM of the ASTUS project, strategies were implicitly defined in the manner of representing standard, i.e. step-by-step procedural knowledge. The fact is that we need not only to represent strategic knowledge to allow efficient problem solving, but also to depict it explicitly enough to be able to teach it, supervise the learner, and give appropriate feedback.

Since we still deal with simple problems, simple or trivial strategies are defined. Examples of such strategies could be: “When given a choice, always prefer methods that involve less additional unknown values”, or “When given a choice, it is always better to apply the most specific rule”. Structured strategies can also be defined: “Try to gather a sufficient number of equations including the desired unknown value, then build an equation system and solve it”. Note that there is no indication on the methods to use to obtain those equations. The effectiveness of a strategy in solving the problem is of little importance at this point. The important aspect is the ability to represent it with the KRM.

Our goal/procedure based KRM is insufficient to represent resolution strategies. It handles domain concepts only, whereas strategic knowledge needs explicit handling of the goals/procedures to represent more abstract reasoning. Strategic knowledge supervises the problem resolving process by building complex procedural knowledge dynamically. Since it is more abstract, a strategy is equivalent to a set, often large, of compatible complex procedures. Representing this set takes modeling and computation time, and is of little pedagogic use. Another particularity worth noticing is the fact that several strategies can be applied simultaneously, as long

as they are not conflicting. For example, we can easily imagine cases where the first two examples of strategies given earlier conflict, and other cases where they don't. It's up to the domain expert to decide what to undertake when they do.

Pragmatically, strategies can influence problem solving in three different ways: (1) When several procedures can satisfy a goal, and choosing the right one according to the situation is part of the domain knowledge. A simple example is to choose between applying Ohm's law and Kirchoff's law to calculate a current value. (2) When processing a complex procedure generates several goals that are required to be fulfilled without a particular order, and ordering the sequence optimally is part of the domain knowledge. Again, a simple example could be applying Ohm's law to find a resistance value, and discover that the corresponding current and voltage values are unknown. If we suppose that beginning with the search of the current is optimal in the given situation, we must be able to depict that fact explicitly. (3) When fulfilling a goal requires to build a complex procedure that doesn't exist in the knowledge base. The third of the examples given above is a good example of that. If the goal to fulfill is “find value of X”, and the strategy is “Try to gather a sufficient number of equations including ... (see above)”, the optimal solution to a particular problem could easily be a set of goals/procedures that never occurred before during problem solving, nor is depicted in the knowledge base. See section VI to see what additional benefit this approach could allow.

Because applying a strategy implies to make decisions, every time a choice is to be made, criteria for comparing candidate goals or candidate procedures must be defined. This is done by adding information to the definitions of goals and procedures. We call such information “strategic metadata”. These metadata can have a static content, or be dynamic, with the content depending on pertinent elements from the problem, or the solution graph. The complex procedure titled “Apply Ohm's law to calculate a resistance value”, for example, has the following static metadata:

- A procedure searching for a resistance value;
- A procedure implying looking for a voltage value;
- A procedure implying looking for a current value;
- A procedure implying looking for 2 values;

And, in the middle of a problem solving process, it has the following dynamic metadata:

- A procedure implying calculating an *unknown current* value;
- A procedure implying calculating *1* unknown value;
- A procedure that wasn't used in the past 3 steps on the same resistance;

The dynamic aspects of metadata are written in *italic*. Additional metadata can be added, and the more elaborate and numerous the strategies are, the more metadata we'll need. The previous metadata allow the simple strategy mentioned in the very first example to choose appropriate goals and procedures. The last metadata can be used with a strategy that proscribes senseless loops.

To depict a strategy, the following information is needed: The strategy title, the labels it prioritizes when choosing among goals and procedures, and the activation/deactivation conditions. The latter must be written in terms of concepts related to the domain, and thus, additional, more abstract concepts are defined in the semantic part of the knowledge base. For example, the “number of unknown values related to a resistor” is a new concept to be created and integrated. The activation/deactivation conditions represent the fact that at a certain point of the problem solving process starting applying a particular strategy can be interesting, or there is an advantage in switching from a strategy to another one.

The depiction of strategies is a recursive process. Two or more strategies supposed to be activated in sequence, in disorder or simultaneously, can be seen as a strategy of a higher level. One can imagine general strategies that transcend the domain of DC circuit analysis, and can be applied to another domain of physics.

V. USE OF THE KNOWLEDGE BASE INSIDE THE ITS

Our ITS architecture is decomposed into a number of semi-independent agents. The expert agent accesses the domain-related knowledge base while solving problems and giving correct or optimal answers upon request from other agents. The learner model agent is responsible for modeling the learner knowledge and collecting information about her/him during the problem solving tasks. The objective is (1) to identify and understand the current learner actions, (2) to predict his future behaviour and (3) to evaluate the learner’s knowledge. These processes are commonly known as model tracing, prediction and knowledge tracing respectively [2]. They are currently under implementation using Bayesian networks. The learner model agent assesses the learner knowledge in terms of goals and procedures defined in the knowledge base. The tutor agent’s function is to interact intelligently with the learner and provide adaptive feedback. Finally, the interface agent maps the knowledge on the different graphical components showed on the user interface; it also provides a communication channel between the learner and the tutor agent. Fig. 3 shows an overview of the architecture of the ASTUS ITS.

The introduction of strategies in the domain knowledge base can facilitate the learner model agent. Successfully identifying the strategy the learner is following can contribute to narrow the search when trying to identify the procedures the learner is using. Since the number of possible strategies is often less than the number of candidate procedures, once the strategy is identified, it can be used as a criterion to distinguish the procedures used in ambiguous cases.

VI. FURTHER WORK

As mentioned earlier, using Description Logics to represent the semantic knowledge of three distinct domains has shown some benefits, but also several limitations. Currently, there is a

work in progress to find another language to represent the semantic knowledge and improve the reasoning over it without having to change the theoretical structure of the KRM. A combination of Description Logics and a rule-based approach such a SWRL is considered [5].

Concerning strategies, the initial design and the theoretical research related have been performed. The next step is to improve the existing ITS structure to allow the interpretation and use of the strategic knowledge. The agents of the current version are not able to deal with strategic knowledge and beneficiate from it. Improving the agents, defining further the structure of strategic knowledge and updating the authoring tool is the aim of future works. Note that the fact of being able to build new complex knowledge using strategies as guides is very promising. If handled and organized correctly, it may allow the knowledge base to infer additional knowledge, and the ITS could learn new procedures/strategies while assisting the learner. This is a long term work that is planned after the complete implementation of strategy handling is done.

VII. CONCLUSION

Knowledge representation is important in an ITS, as it is both needed in the internal reasoning process, and for transmitting that knowledge to the learner. Particular attention must be paid when designing reusable, domain-independent KRM. Our way of representing knowledge has proven to be generic and effective enough to describe two, and soon three, different domains; others are planned to be represented. After briefly introducing our previous work, we have described a way of representing semantic, procedural and strategic knowledge related to basic DC electrical circuits problem solving. We showed how the conceived knowledge base is used, and how using strategies can improve its efficiency.

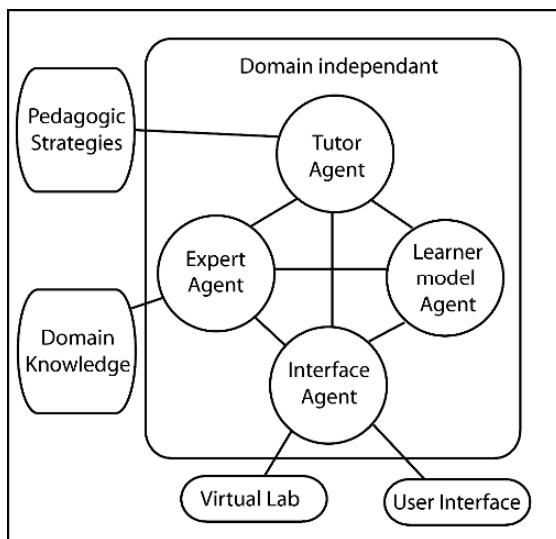


Fig. 3. Architecture of the ASTUS ITS.

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Content and e-Learning Provision Services Management Framework: Architecture and Session Profile

Theodore Apostolopoulos and Anna Kefala

Department of Informatics, Athens University of Economics and Business

76 Patission st., 104 34 Athens, Greece

Tel.: +30 2108203234, 900, Fax: +30 2108203909, E-mail: {tca,ask}@aub.gr

Abstract-During the last years, we are witnessing an explosion in WWW, communication and device technologies that enables access to e-Services via diverse means and locations. Systems that present different features and functionality, and offer various content and e-learning services are implemented en masse.

Proposed management framework aims at acting as a facilitator among content and e-learning systems, clients, underlying communication infrastructure and access devices, content and provided learning/delivery methods, offering an integration management architecture, while at the same time, acts as a broker for e-learning and content providing systems. Our framework is session profile centric, since a key characteristic of proposed architecture is the dynamic creation of user session by detecting and managing information and parameters that are either derived by stored profiles or change dynamically at each user session with middleware and concern user, broker or service current context .

In this paper, we present content and e-learning provision services context, resulting in functional requirements and design principles for our management and brokerage framework. We outline key features of proposed architecture with emphasis to session profile parameters and middleware components, and conclude with summarizing the main points of proposed framework.

I. INTRODUCTION

Nowadays, electronic services have emerged as the prevailing new trend in service provision area. Numerous applications and systems providing e-services are constantly developed, offering diverse functionalities to potential clients. Content and e-learning provision services hold a remarkable share in the e-services market worldwide. Thus, a plethora of diverse e-learning and content provision systems are implemented, offering different or complementary features.

Plurality of implemented systems and technology advancements have offered consumers the option to acquire access to e-services provision and enjoy quality of service from home, from work, or even while being on the road. Lately, research focuses on offering personalized services to users according to their profile, preferences or context. Since status in service provisioning area is characterized by multiplicity of applications, another active research area is directed to standardization issues and systems' integration. Another trend concerns Learning Resource Brokers, which act as electronic marketplaces for offering and demanding learning resources [1].

Taking into consideration, status and trends in content and e-learning provision area, we realize that designing and implementing a content provision service is a complicated procedure, since there are many factors that form and affect such a

service. These factors include the type of offered service, the actors that participate and interact with service provision system, the content that is provided, the delivery methods and protocols, the communication infrastructure and means, and the users' access devices.

Most times, only some of these factors are supported, resulting in systems that offer partial services or present deficiencies when information management is concerned. Therefore, we have identified lack of a management framework that would bridge the gap among the several parameters forming a content providing service and would consist a balanced solution based on conflicting requirements [2]. Thus, we propose a middleware that offers a consistent management scheme for the whole content provision service, while at the same time acts as a broker among numerous content providing systems.

In the following sections, we first designate content and e-learning provision services context, resulting in defining functional requirements and design principles for a management and brokerage framework concerning these services. We, then, present key characteristics and features of proposed architecture, emphasizing session profile parameters and middleware components, and conclude with summarizing the main points of the proposed management framework.

II. CONTEXT ANALYSIS

Content and e-learning provision systems presenting different features and offering diverse services are implemented en masse. Taking into account provided services and features, different classifications are feasible, starting from simple web servers, Content Delivery Systems (CDS) or Content Management Systems (CMS) and ending up to more complex systems such as Learning Content Management Systems (LCMS) and Learning Management Systems (LMS).

Content delivery and management systems focus mainly on content creation, management, delivery and contracting with customers, while learning management systems are usually learner oriented, focusing on learner management and progress tracking [3]. An epitome of such systems key characteristics includes support of on-line or off-line access to (learning) content, support of synchronous or asynchronous learning, access via diverse communication technologies (considering both network infrastructure and communication protocols), access from fixed or mobile devices, support of e-learning specifications and standards, and others [4].

Learning Resource Brokers facilitate learning content ex-

change between providers and learners, implementing specific functions, such as: browsing and searching of resources, displaying information and metadata concerning these resources, resource reservation and management, managing transactions concerning buying and selling resources and delivery of resources [1].

During the last decade, we are witnessing an evolution in network and communication technologies field, which has enabled consumers to access electronic services on the Internet via diverse means and locations. When first content provision and e-learning applications were designed and implemented, access to offered services was feasible and efficient mainly within campus or corporate environment, where high capacity networking infrastructure was available, while the most popular access device was a desktop computer. Nowadays, users of e-content and e-learning provision services, access them from anywhere, deploying diverse types of devices.

More specifically, a user might enjoy e-content and e-learning services from home, connected through narrowband technologies like PSTN or ISDN lines, or through some more bandwidth providing means such as DSL or cable modems; from work, within an intranet; or from a university campus having broadband connectivity; or while being on the road via some wireless/mobile network. Consumers, now, access e-services not only utilizing a desktop computer or laptop, but also other devices such as PDAs or cellular phones. Diverse devices support different content presentation and process capabilities, creating an heterogeneity of client capabilities and increase in number of accessing methods [5].

Nevertheless, consumers expect to enjoy the same kind of services no matter what access mode they choose at a time. In this direction, research efforts focus on defining user's context. Context awareness is lately designated as a key parameter for adaptive and technology independent e-services. As *context*, we can consider any information characterizing the environment of an application or service that can be exploited in order to improve system's behavior and offer adaptive, personalized and flexible services [6].

In Ref. [5], they present a context framework that facilitates the development and deployment of context-aware adaptable web services and they include consumer's identification details, type of client device, location, communication and format as context elements. In Ref. [7] they introduce a context aware "follow-me sessions" management architecture within an ad hoc networking environment, where a client is allowed to switch service provider when needed.

As depicted in [8], the "Cooltown" project allows users to discover services that are in the user's vicinity, so that services that are close to the user are returned by the service discovery mechanism. In the same direction, "Context Toolkit" provides functionality to discover services using contextual information, allowing for the description of services by means of white and yellow pages that include contextual information. In the same paper, they present an approach for service discovery that uses ontologies to capture the semantics of user's query, of services and contextual information (concerning mainly location issues) that is considered relevant in the matching process.

In Ref. [9], they propose a context aware ubiquitous learning environment consisting of a peer-to-peer content access and adaptation system, a personalized annotation management system and a multimedia real-time group discussion system, emphasizing on a context model and a context acquisition mechanism for collecting contextual information.

Some platforms, usually LCMS, implement delivery interfaces that support dynamic content serving, by modifying content to reflect a certain user-personalized look and feel [10]. They offer adaptation to user local and regional characteristics and stored learner's profile, as in [11]. Some systems offer e-learning service adapted to students learning style, which is identified by their abilities, learning attitudes and preferred ways of study [12], while other are based on a model which expresses goals, preferences, and knowledge of individual users, thus supporting ability to adapt to diverse learners [13].

Most implemented content and e-learning provision platforms are not flexible enough to meet dynamically altering user needs and connection characteristics, while even the more sophisticated ones, usually support either personalization of content according to user profile, or emphasize user-service vicinity factor, but still do not take into account all parameters and factors that might differentiate from session to session [14].

Considering all aforementioned issues, we have noted the lack of a *Content and e-Learning Provision Services Management Framework* that would manage all diverse aspects of such services and would act as a broker among content and e-learning providers and users. We introduce the notion of a *broker* or *mediator* that communicates and cooperates with a number of content providers, offering a uniform interface and environment to the user. In this case, each time a client requests a content providing service, she is first connected to the broker, who is then responsible for gathering and managing all required information concerning current conditions, characteristics and availability of "represented" content providing systems, as well as the characteristics of current service request. Combining all this information with user's Service Agreement, the broker forms the session profile and decides on whether to serve current client's request (the best feasible way) or not.

III. ARCHITECTURE

When designing and implementing a content or an e-learning provision service, several factors ought to be taken into account. The main identified factors include learning content, learners, tutors, content providers, network and device technology, infrastructure, type of offered service, users' requirements, communication protocols and educational methods.

A principal issue when considering a content providing service is the invocation –upon a client's request– of a session establishment mechanism in order to provide access to services according to current session profile. This mechanism evaluates a set of parameters forming the current context of service delivery in order to decide on request's admission or rejection and consequently create a new user session in a dynamic and flexible way. The information that defines a session profile, includes data that are relatively static and are derived from

stored profiles of system entities, as well as dynamic ones that might vary per session and are gathered on real time terms.

The **Session Profile** covers the following axes:

- *User request parameters* (dynamic). It comprises user identification parameters and requested service identification elements.
- *Stored user profile* (static). It comprises information concerning identification elements, personal information, regional and language settings, user background, history of interactions with broker, user preferences, security information (authentication methods and security elements, such as username/password or certificate) and payment methods.
- *User SLA* (static/dynamic). User Service Level Agreement (SLA) is some kind of a contract between user and broker that defines the type and level of provided services. SLA is usually defined during registration procedure, but sometimes it might be updated at the time a new request is issued. SLA is related to Quality of Service (QoS), which contains various constraints and requirements, in terms of network bandwidth and response time parameters on one hand, reliability, availability and cost on the other hand.
- *User current context* (dynamic). It comprises information describing user's current context and concerns her current location, time, access device capabilities (concerning both hardware and software constraints), type of network connection (wired or wireless, narrowband or broadband) along with its characteristics and limitations.
- *Brokerage and management service context* (dynamic). This information mainly concerns the broker's resources availability and overall system status. Communication network's condition, during the time the request for connection is issued (network load, available bandwidth, etc.), combined with the potential load introduced by the new connection is included.
- *Service context* (dynamic). Service context includes service profile, networks and protocols for service binding, devices and platforms for service execution, availability and status of involved providers.

A. Functional Requirements and Design Principles

After presenting the key issues concerning a content and e-learning provision service, we identify the main *functional requirements* regarding the management of such a service.

Since many systems providing content or e-learning services have already been implemented; the proposed management framework should support any applications, which follow some basic standards. This is ensured by using specific Application Program Interfaces (API) for each software module; API that facilitate and enable communication between the service management system and content provision systems.

The management framework should support simultaneous management of more than one content delivery or e-learning systems, acting as a broker or mediator for systems that offer similar services and probably similar content.

As far as content is concerned, various multimedia content

types must be supported, while delivery is realized depending on current conditions each time a service is requested. Management framework should support different content delivery modes/means with reference either to time (synchronously/asynchronously, real time or not) or to participation mode (self-paced or in a collaboration group). Another requirement related not only to content, but to telecommunication infrastructure as well, is supporting various communication protocols, such as RTP, HTTP, FTP, etc.

Framework's functionality should include management of administration issues related to users, together with procedures for Service Level Agreement creation and management, which defines offered services level.

A brokerage and management framework should support different roles/actors, such as receivers of content or learners, content creators, content providers, facilitators and service administrators or administrative staff.

An e-service management framework should support deployment of a wide range of available network technologies and access devices in order to provide access and high availability to users, despite network connection's characteristics.

Generally, when considering a system or an architecture, certain basic principles concerning design and functionality should be defined and followed through out the implementation of it. As far as proposed framework is concerned, main *design principles* are stated here:

- Flexibility and adaptability.
- Framework should be generic enough to cooperate with different applications and support various network and device technologies. Design should support openness and interoperability, in order to enable seamless interaction and integration between different systems.
- Configurable and component-oriented.
- Extendable and scalable.
- Design should follow international standards related to content, user profile, communication and cooperation with content delivery systems, network technologies and devices, tools and development platforms and environment.
- Distributed and decentralized architecture.
- Security, reliability and high availability.
- Quality of service support.

B. Architecture and Components

In the proposed management framework, we choose a middleware architecture and we consider an intermediate layer between some content provision application and the underlying communication infrastructure [2]. Beyond its role as a facilitator for the communication between upper and lower layers, the middleware is also responsible for gathering all required information in order to implement a consistent management scheme for the whole service, including communication between user and system or among system components as well.

The proposed middleware is composed by several components in order to support flexibility, adaptability, openness and scalability. Component oriented design allows a complex system to be considered as an arbitrary number of smaller cohe-

sive components. Each component comprises agents that implement component's functionality and facilitate communication both within middleware and with external entities.

Proposed content providing service management framework is based on a *3-tier architecture*. The lower layer, concerns the management of access devices and network/communication infrastructure. The later includes not only means of physical connectivity and technological issues but also supported communication protocols. The upper layer of proposed architecture is occupied by some content or e-learning provision application. There are no special restrictions regarding the characteristics of such an application. It might vary from a simple web server to a sophisticated and complete content providing platform. Depending on functionality and characteristics supported by content provision systems, middleware undertakes a more or less active role (by activating specific agents) at the content providing service, acting solely as a broker or providing complete management services. The intermediate layer concerns the proposed management middleware.

In the next paragraphs, we present the proposed framework in the light of supported management level. More specifically, management is implemented at three different levels, starting from the lower one, which concerns network connectivity and conditions and ending up to the management of the whole service. Different issues are resolved at each level.

Level 1: User's connection with service management system

- User identification, authentication and authorization procedures, that define who connects with the service and what her access rights include.
- Connection type and means, including type of access device and network technology.
- Current connection requirements and characteristics.
- Supported telecommunication protocols.
- Exploration of resources' availability and efficiency in order to offer user a service according to her SLA.
- Specific requested by user service is defined.

Level 2: User's session with service management system

- Content providing methods that are implemented for serving user's request.
- Recovering of user's history data concerning her communication and interaction with service system, in order to ensure continuity with user's previous sessions.

Level 3: Management of the whole content providing service

- Cooperation and communication with content providers, when the service management system is acting as a broker. Determination of supported and offered services. Definition of information exchanged between content providers and service management system.
- Management of service provided contract with content providers (P-SLA).
- Management of service provided contract with content clients (C-SLA).
- Client's profile creation and updating.
- Content provider's profile creation and updating.
- Content (metadata) management.

While further analyzing the proposed architecture, different components are defined, which deal with implementing spe-

cific functionalities. At each level, communication infrastructure, service and content providing management might correspond to one or more components depending on the degree of system's complication and provided functionality. The components that compose proposed service management architecture are next described.

Most components –depending on their complexity and implemented functionality– include sub-components. One or more agents (related with each component) undertake communication with external entities. Each component maintains and manages a set of information concerning the system entities or the actors that interact with the management system, in order to implement the specified functions. Information is organized and maintained in Management Information Bases (MIB).

In Fig. 1, a reference architecture for the proposed management framework is depicted. More specifically, the management framework comprises a set of components with their sub-components, along with MIBs. Clients access broker services via various devices (laptop, desktop PC, PDA, cell phone), while diverse providers (CMS, LCMS, LMS, etc.) use broker services, communicating by using network infrastructure and communication protocols.

The main component (*Service Management Component*) is the one that dynamically creates and manages a session profile serving a user's specific request, by taking into account various parameters in order to offer adequate quality of service and ensure new session's feasibility. These parameters are managed by different components of the middleware in a view to meet requirements for flexibility and implementation simplicity. This component undertakes the role of the service manager in our management architecture and acts as the heart of the system. It is also responsible for coordinating components' interaction.

The Service Manager either initiates and creates a user session or rejects user request in case that service prerequisites are not satisfied. As soon as a new session is approved, an agent is associated with the specific session, monitoring and managing it during its termination. We *note* that content or e-learning service is not provided to user through the broker, but through direct connection with specific provider or providers. This component manages all required information so that at any given moment, an overall snapshot of system status can be retrieved and formed (active sessions, service availability, resources availability, number of served users, etc.).

The component that handles content provision and management is identified as the *Content and e-Learning Provision Service Management Component*. It is the component that manages content providing methods on one and content on the other hand, through two sub-components, the *Content and e-Learning Service Provision Methods Management sub-Component* and the *Content Management sub-Component*.

As far as the content providing methods are concerned, we have identified four different types based on time and grade of collaboration allowed among users: (i) asynchronous, self-paced, (ii) synchronous, self-paced, (iii) asynchronous, collaborative (the user is a member of a group/team and collaborates with other members) and (iv) synchronous, collaborative.

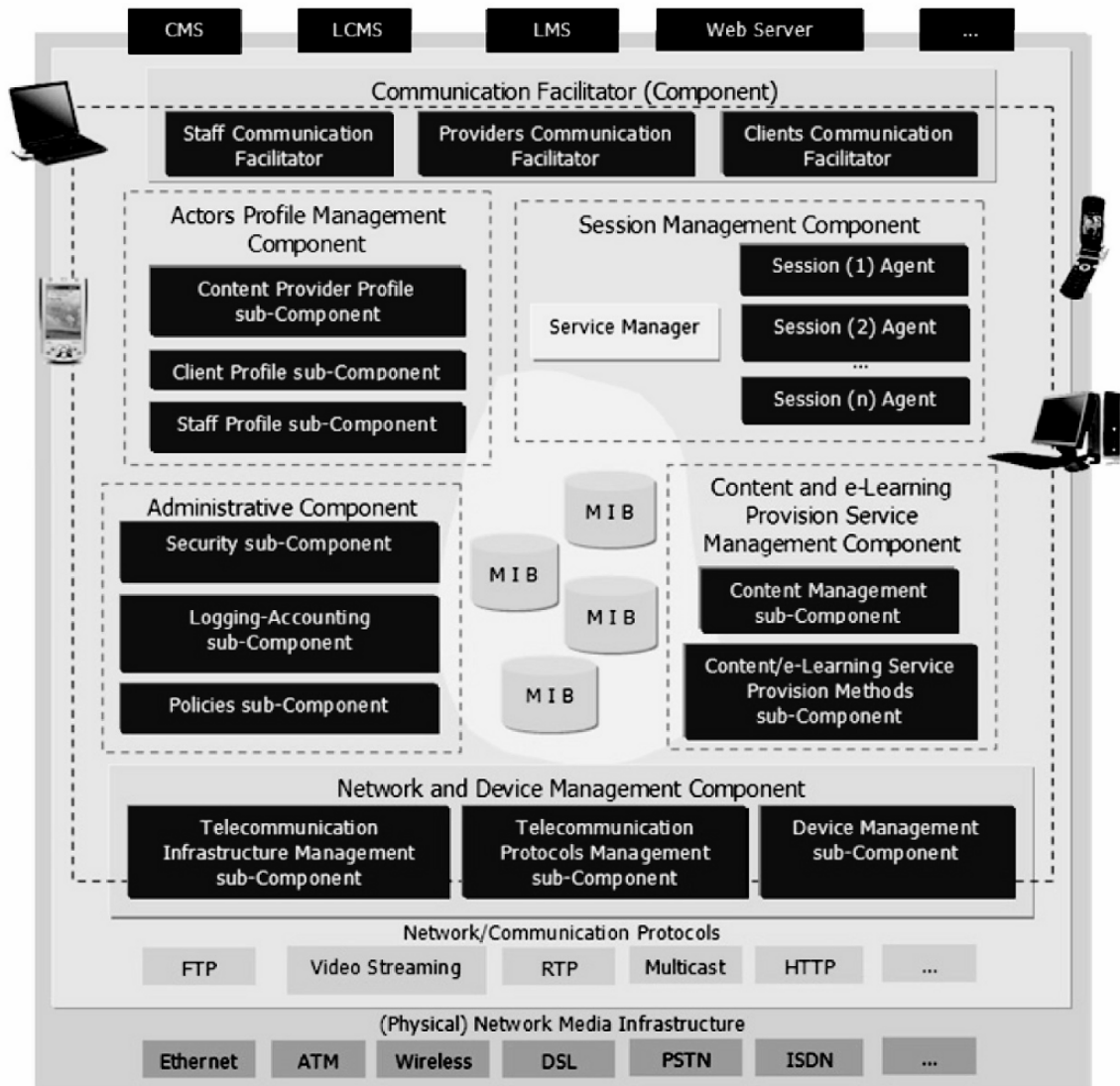


Fig 1. A reference architecture for the proposed management framework

Note: The last two types mainly concern e-learning services.

As far as provided content is concerned, the sub-component is responsible for managing the metadata which describe content and its characteristics. It maintains necessary information that concerns content availability and management of alternative versions of the “same” content, since a key requirement is offering same kind of service to users accessing broker services via diverse devices and connection characteristics. Thus, in order to serve user request as efficiently as possible, depending on current conditions and parameters and based on content transmission/transfer requirements and content presentation specifications, the broker has the possibility of choosing spe-

cific content version each time. For example, when a user – using a low bandwidth and limited presentation capabilities mobile phone – requires content, the broker should select a version of the content that would not be so fancy or resource demanding; whereas for a user on a personal computer at a university campus, the broker could provide a different version of the “same” content that would be more resource-consuming.

The component that manages all administrative and policy related issues that arise from providing an electronic service is the *Administrative Component*. This component deals with security issues related with service providing and system active entities interaction. It also manages issues concerning user

registration procedures and the SLAs with users. This component is responsible for maintaining and logging information concerning active entities' interaction with the system, as well as accounting and user charging and billing issues. Other functionality offered by this component is the management of issues concerning content providing policies, users' subscription policy, certification (in case that it is provided) of specific units of content (or specific courses) attendance, charging and billing policies and methods, security policies, etc.

Given the complexity and multitude of administrative issues, three sub-Components have been designed for managing them: *Security issues Management sub-Component*, *Logging and Accounting Management sub-Component* and *Policies Management sub-Component*, dealing with corresponding aspects.

Within the proposed architectural context, certain roles or active entities of the management system are identified. These are the users of service such as content providers and content clients, system administrators and other administrative staff. *Actors Profile Management Component* is responsible for collecting and managing all the information that forms the profile of each active entity. For that reason, it is decomposed in three sub-components, one for each actor category identified within the system: *Clients Profile Management*, *Content Providers Profile Management* and *Staff Profile Management* sub-Components. Taking into account the fact that some profile characteristics and elements change dynamically and might vary from session to session, a necessity for updating users' profiles with dynamically varying elements is emerging, each time a new session is initiated.

Network and Device Management Component is the one that implements the collection and management of the information related with the underlying network infrastructure and available communication and collaboration technologies, as well as the information concerning access devices' characteristics. The information that concerns access devices comprises not only technology oriented characteristics but also device's software capabilities. This component manages all required information concerning physical (*Telecommunication Infrastructure Management*) and logical (*Telecommunication Protocols Management*) connectivity between active entities and service management system on one hand and among system components on the other. Some information concerning telecommunication infrastructure is relatively static, while other parameters change dynamically. This fact brings about the need for collecting dynamic information during a new session approval and initiation phase. Therefore, communication agents undertake the task to detect current connection's characteristics.

Finally, the component that manages communication and interaction of (external) active entities with the service management system is the *Communication Facilitator*. A sub-Component is implemented for each active entity category identified within proposed architecture: *Clients Communication Facilitator*, *Content Providers Communication Facilitator* and *Staff Communication Facilitator*.

Such a management framework can be deployed in various areas of electronic services market. It mainly focus on managing and brokering content and e-learning service provision, but

since it is flexible and adaptable, it can also be applied in other sectors, where content is the key commodity of service provision.

IV. CONCLUSION

Proposed management framework presents a brokerage scheme for diverse content and e-learning providing systems, offering a common interface and service management context to users. Management of various services is implemented on a session-centric approach. The Session Profile is created dynamically, taking into account several parameters and information concerning session's context, either static or dynamic that might vary from session to session, in a view to ensure quality of service for the users.

Proposed framework can be deployed not only within the e-content and e-learning service domain, but within the e-services provision market in general.

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Sandesh – An Automatic Email Response System

Aparna R., Sasikumar M.
Educational Technology Division,
Centre for Development of Advanced Computing,
Kharghar, Navi Mumbai-400614
India
{aparna, sasi}@cdacmumbai.in

Abstract - E-learning has become very popular in the last few years and more and more people are switching to this mode of education. The primary mode of communication between the faculty and the students, in an e-learning scenario, is email. This mode of communication requires the faculty to answer the same query a number of times and this increases the burden on the faculty. We propose an email response system called Sandesh which addresses this issue. Sandesh uses NLP techniques to identify previous query-responses which match the new query and forwards the same response to the student. It also caters to fixed format queries. Sandesh also allows students to bypass it and directly contact the faculty. Further enhancements to support web and other local resources to generate responses are in progress.

I. BACKGROUND

There has been a tremendous growth in information and communication technologies in the last few years. Computers are fast entering every aspect of our life. Right from banking, income-tax, railway reservation, aircraft reservation, to even education, computers are leaving no fields to capture. When we talk about education, we can see the popularity that e-learning has gained in the educational circuits. Advances in the hardware technology and the steady reduction in hardware cost have made it possible for many institutions to afford the online mode to impart knowledge.

E-learning is bringing significant amount of changes in the educational models. This includes shifting from a teacher-centric model of education to a learner-centric model of education. The 'anytime-anywhere' paradigm of education has become popular with e-learning. This style of learning enables the learner to learn the concepts at his pace. These style changes are becoming acceptable to people. One major area of concern in e-learning is the teacher-student communication.

In a traditional classroom lecture model, the faculty and the students interact face to face when the faculty delivers his lecture. Here, whatever the faculty speaks every student gets to hear. Similarly, if a student asks a query to the faculty, every student hears the query as well as the faculty's response to it. Hence, the probability of the same query being asked by someone else is very low. The only case of repetition, here, may be when a student is absent for a lecture. Since the student was not present during the session, the teacher may get queries which may have already been discussed during the session and the faculty would have to repeat his explanation for the same.

Some of the drawbacks of the traditional model are:

- Given that a weak students' grasping capacity is low, they will need more elaborate explanation of concepts

which may not be of interest to the other students.

- It may happen that a bright student asks a query and the faculty responds to it with a 'to-the-point' answer. But this may not be useful for a weak student with the same query as he may find the explanation inadequate. In such a case, the student may choose to just keep quiet and as a result his query will never get resolved.
- Sometimes the faculty may need some time before answering to a certain query as he or she may want to look up some material before answering. Most of the time this is not possible in the typical classroom lecture mode. Even if the faculty tells the student that he would answer the question later, it is possible that he may forget about it and the student may not remind him about the same.
- Shy students may not ask their queries in the class. Such students may choose to ask their queries to the faculty after the lecture, in which case the other students are not benefited by the same, or may choose to not ask the question at all, in which case their doubts never get cleared. In any case, shy students never ask questions during the first few lectures of their course - hence their basics remain unclear often.

Many of these drawbacks are non-existent in the online learning model where the primary mode of communication between the students and the faculty is via emails or discussion boards. Email encourages shy students to come out of their shells and ask their queries. Also, since this mode of communication is one to one, the faculty can frame his response depending on whether the student is a bright student or a weak student. Thus, a response to a weak student can be elaborate while a response to a bright student can be precise. This mode also gives the faculty the needed time to refer to other materials to answer queries.

One of the biggest issues with this model of interaction is that the number of times a faculty may potentially need to answer a query increases with the number of students. This happens because email being between just two people, others are not aware of the communication. This is unlike a traditional learning environment, where the faculty and students communicate face to face, as mentioned earlier. Though there may be times when a faculty repeats the answer (e.g. when the student was absent in the class), the number of times the faculty needs to do so, does not grow with the number of students.

Hence, unlike in a normal classroom lecture where every

student can hear the communication between the faculty and any other student, in an e-learning mode, when a faculty responds to a particular query the remaining students are not benefited by the same. As a result the faculty has to answer to the same query several times. This can burden the faculty tremendously.

The other issues with email communication are:

- Since emails are not a completely reliable mode of communication, they can be lost without information. Thus, if a student's mail is lost, he will all the time keep thinking that the faculty has not answered to his query, whereas the faculty would not be aware of any such mail. Similarly, if the faculty sends a response to the student and it gets lost, the faculty will not be aware of it.
- It is possible that the faculty is on leave but the students are not aware of this and send him mails. Hence the faculty is unable to reply to the queries but the students only get a picture that the faculty is not responding.
- It is also possible that the faculty is busy with some other work when he receives the mail, though he does manage to read the query and decides to respond to it at a later time. But then he forgets this later and as a result the query remains unanswered.

One can argue that one can create email groups, so that everyone can see what question a fellow student has asked and hence the faculty may not have to answer the same query again and again. But again, when a student posts a query he may not necessarily check all the earlier mails in the group to see if the query had been asked earlier or not. And all the other above mentioned problems still remain. To add to this, email groups may cause shy students to get into their shells. Hence email groups offer no significant benefits, except for sharing.

In this paper, we propose an automated email response system (Sandesh) which addresses many of these concerns. The next section introduces the idea and gives an outline of such a system. Section 3 looks at relevant solution and related work. Section 4 discusses Sandesh's approach in detail. In Section 5 we talk about the current status of Sandesh. Section 6 concludes the paper. Section 7 talks about the future work and enhancements.

II. AUTOMATED E-MAIL RESPONSE SYSTEMS

Most of the above discussed problems is reduced to a large extent by having a system to automatically respond to queries via emails. The students' mails will be intercepted by this system which checks if a response to the query is already available. If yes, then it forwards the response to the student. Thus the faculty is freed from the burden of replying to the same query over and over again. Automatic Email response systems are feasible today, thanks to sophisticated Natural Language Processing techniques and tools, information retrieval models and web technologies. Automatic Email Response systems can also integrate other sources in the interaction circuit. These include:

- Web: A lot of material will be available on the

institution's website which can be made use of to answer queries.

- Local resource: Institutions will have course handbooks which will have sections like Frequently Asked Questions (FAQs) which will answer a lot of queries.
- Query Response Repository (QRR): These systems generally maintain a repository of previously answered queries. The repository is updated regularly with new queries and responses.
- Faculty: If no response is obtained from the above mentioned resources then the system contacts the faculty to get the response.

Of the above listed resources, the faculty is the most reliable but the most expensive resource. The next in line is Query Response Repository. The system can improve on the quality of response retrieval by making use of good natural language processing methods. The next in line of reliability are the Local Resources. The only problem with this resource is that we may not find the exact response to a query. The last reliable resource of the four is the web. There is a lot of data on the web but finding relevant data is not easy. Hence the response from this resource needs to be monitored.

This can be combined with the email support for fixed format queries. A number of common queries from students would be for exam results, exam dates, lecture dates, fee schedule, etc. These can be supported by allowing emails with a fixed format subject line like 'Results *StudentID ExamID*' which can be processed easily and a reply mail generated by looking up the appropriate data source. Our system allows for such queries also, by filtering such queries first and processing them separately. Fixed format queries are important since they provide high reliability in response, but they are very restrictive in their scope.

The broad approach of an automatic email response system, to obtain a response to a query, is as follows:

1. Analyse the subject line to see if it matches a fixed format query. Mails with some fixed subject patterns have standard solutions to generate responses.
2. If the subject line is not a fixed type, then check if a response to the query is already available in a repository of old responses (QRR). If an adequate match is found, then forward the response to the student.
3. If no response is found, check the local resources like online handbooks, to find a suitable response and if obtained forward the same to the student.
4. If no response is obtained, then forward the mail to the faculty.
5. All responses from the faculty should again pass through the system so that it can store the response in its repository for future use.

III. SYSTEMS CURRENTLY AVAILABLE AND RELATED WORK

There are a few systems that attempt to reduce the burden of responding to queries. These systems manage pre-formatted

responses to respond to queries, or decide whom to forward the mail to or suggest responses to queries.

Visnet MailFlow [9] is an email tracing system. It decides whom to forward the query to, depending upon the query received. It also keeps track of whether the response to the mail has been sent or not. EmailManager [2] is another system on similar lines. RightNow [7] replies to emails with links to answers. ReplyMate[6] is a plug-in for MS Outlook Express which manages pool of replies and suggests responses to queries from the pool.

IV. OUR APPROACH

We propose an automated mail response system - SANDESH - that will act as a middleman between the faculty and the students. All the queries posed by the students to the faculty is intercepted by Sandesh, which checks its repository to see if the same or similar query has been asked earlier and if a response to it is already available. If yes, then Sandesh forwards the corresponding response to the student; else it forwards the mail to the faculty. The response from the faculty is also intercepted by Sandesh so that it can update its repository. Once it has updated the repository with the faculty's response, it forwards the mail to the concerned student. Sandesh also keeps track of whether a pending query has been answered by the faculty or not.

Thus, the burden on the faculty is reduced considerably, for he does not have to respond to the same query several times, thanks to Sandesh which presents the faculty mostly with unique queries for answering. This is not the only advantage. The question answer interaction often encompasses a lot of specialised knowledge. The growing repository offers a simple and effective device to capture these. The interaction and associated knowledge fragments become accessible to all learners at their own pace - when they need it.

The broad procedure that is followed by Sandesh to perform the above is given below:

1. Check if the mail is a fresh mail, reply from faculty or a follow-up mail. A follow-up mail is a mail from a student indicating he is not happy with the auto generated response received earlier, and want to talk to the faculty directly.
2. If the mail is a fresh mail then check if it is fixed format mail or any other mail.
3. If the mail is a fixed format mail, then execute the corresponding command and forward the result to the student.
4. If the mail is not a fixed format mail, but is a fresh mail, then perform the following sub-tasks:
 - Search the Query Response Repository for a suitable response. If found, then forward the same to the student with a warning that this is an automatically generated response.
 - If a suitable response is not found in the QRR then, identify the faculty who will be able to handle the query. Forward the mail to him and mark the mail request as pending.
5. If the mail is a reply from a faculty then perform the

following tasks:

- Check if the mail is a reply to a follow-up mail or reply to a fresh mail.
 - If it is a reply to a follow-up mail, then remove the corresponding query-mail from the pending list and forward the response to the student.
 - If the mail is a reply to a fresh mail, then perform the following tasks:
 - Remove the corresponding mail from the pending list.
 - Update the Query Response Repository with this query and the faculty's response to it.
 - Forward the faculty's response to the student.
6. If the mail is a follow-up mail then mark it pending and forward the same to the respective faculty.

Currently Sandesh does not include search of web and local resources, since we are focusing on use of previous responses.

Implementing such a system requires addressing a number of design issues. The major ones are discussed below.

A. How to identify similar queries

This is the heart of Sandesh as this will decide how well the system works. Determining similar queries will require Sandesh to check how many useful words of a new mail are present in any other mail. We say 'useful' words because there is no point in counting occurrences of articles/prepositions/conjunctions. We need to understand the domain and find which words would be useful for matching. For example, in an e-learning domain words like 'exam', 'subject', 'course', etc. are important. This matching of ONLY the useful words will improve the result quality. Similarly, a match cannot be one-to-one, i.e. a word 'when' in a query could be matched against a date or time in some other mail. Consider the following example

* When will the MCA entrance exam be conducted this year?

* I heard that this year the MCA exam will be conducted on 13th March. Is this true?

Both the queries above are essentially the same. But there is no 'When' in the second query and no '13th March' in the first. But both these seek the same information and hence should be matched for effective output. Thus a plain word to word match will not do. We will need to consider synonyms and other related words based on the domain for matching.

Another issue in matching is converting all words to their root form. For example, the words 'actively', 'active', etc. should all become 'active'.

B. Relevance of the response

The above process could give us some best response to the query. Simply choosing a best response is not always advisable. There may not be 'adequately' matching queries observed earlier; these are cases where the query should be sent to faculty for answer. The system needs to detect such cases. For this purpose, we set a threshold for every match in

the QRR. This threshold, among others, depends on the mail size. It depends on the number of ‘useful words’ in the query-response set. If this number ≤ 4 then the threshold is set to 75%. For everything else, the threshold is set to 25%.

C. Bypassing the system

In general, the student may not always be satisfied with the automatically generated response and may want to ask the same query directly to the faculty. In this case he will need to bypass the system. In Sandesh, we generate a subject for every automatic response and request the students to reply to the mail without modifying the subject line in case they want to bypass the system.

D. Identifying the faculty to whom the response needs to be forwarded

In general, a course may involve multiple faculties. Sandesh needs to be able to figure out which faculty is most appropriate to answer a query. A variant of the matching algorithm used for finding similar queries could be used here, since this can be viewed as a mail classification problem. Currently, Sandesh assumes a single faculty account and does not address this problem.

V. SANDESH AT WORK:

At its current stage, Sandesh intercepts a query and performs the following actions:

a) It first checks the subject of the query and compares it with its command formats. If ascertained as a fixed format mail, then Sandesh performs the defined action for the command. The action to be performed can vary from sending a standard response to fetching some dynamic content from the web, like getting a module result of a student.

The Command Structures for Fixed Command mails are defined in a Command File, which is an XML file. We use XML structure because it is one of the popular and standard ways of representing data. Also, XML allows us to have custom-defined tags to represent the data. There are several ‘commands’ defined in the Command File.

A command is composed of several keywords and variables. The variables in a command are used to retrieve dynamic content. For every command, an action to be performed is defined. The action can vary from sending a predefined answer to retrieving data from the web. If a query has a subject similar to any of the command structures, then the corresponding action is performed and the result is forwarded to the student.

All command structures have two parts – a ‘Definition’ part as seen in ‘Fig. 1’ and a ‘Command’ part as seen in ‘Fig. 2’. The ‘Command’ part defines the structure a command can take, i.e. it defines the variables and the keywords that constitute the command. For example, ‘Fig. 2’ defines a command with the structure *MODULE RESULT ROLLNO*, where *MODULE* and *ROLLNO* are the defined variables and *RESULT* is a keyword. This command will match a subject line, only if the subject line

contains the three specified components: the word *RESULT* and two other words, one mapping to a *ROLLNO* and one mapping to a *MODULE*.

The ‘Command’ part also defines the action to be performed in case the subject of any query matches this structure. The *REPLY* tag, seen in ‘Fig. 2’, defines this. In this case, information is retrieved from the web using the values of *MODULE* and *ROLLNO*. The data retrieved thus, will be sent to the student as response.

What words can map to a variable in a command is defined in the ‘Definition’ part of the command. For example, ‘Fig. 1’ defines a variable *ROLLNO* as a structure containing one alphabet followed by 7 digits. Thus, if a subject line has a word starting with an alphabet followed by 7-digits then, it could be identified as a value of *ROLLNO*. Similarly, the variable *MODULE* can have a value ‘java’ or ‘c’ or ‘webprogramming’ or ‘networks’. Any of these words occurring in the subject line could be identified as a *MODULE*. No other words will correspond to a *MODULE*. A command can have many such variables defined for it. The variables are defined using POSIX’s regular expressions.

```
<DEFINITIONS>
  <ROLLNO match=" [[:alpha:]] [[:digit:]]{7}" />
  <MODULE
    MATCH="(java|c|webprogramming|networks)" />
  <TIME match="(time|date)" />
</DEFINITIONS>
```

Fig. 1 - Definition part

```
<COMMAND>
  <VAR value="MODULE">
  <WORD value="RESULT">
  <VAR value="ROLLNO">
  <REPLY>
    <URL method="POST" value="http://202.141.152.1/Rollno">
    <FORMVAR name="moduleid" value="MODULE">
    <FORMVAR name="rollno" value="ROLLNO">
    </URL>
  </REPLY>
</COMMAND>
```

Fig. 2 - Command part

Thus, for the command structure defined in ‘Fig. 1’ and ‘Fig. 2’, a subject line of the form *d025700 RESULTS java* will match. Here, ‘d0257009’ is the *ROLLNO* and ‘java’ is the *MODULE*.

b) If the mail is not a Fixed Format mail, then Sandesh checks its Query Response Repository (QRR) to see if a

similar query has been asked before. The QRR is also an XML file, which is a repository of previously asked queries and responses to them.

An example query-response pair stored in the QRR is shown in 'Fig. 3'.

```
<REPLY>
  <WORD val="FINAL"/>
  <WORD val="YEAR"/>
  <WORD val="STUDENT"/>
  <WORD val="WHICH"/>
  <WORD val="CST"/>
  <WORD val="LEVELS"/>
  <WORD val="ELIGIBLE"/>
  <QUESTION>
    <![CDATA[ I am a final year student. Which levels
of CST am I eligible for?]]>
  </QUESTION>
  <MIN-MATCH val="25"/>
  <BODY>
    <![CDATA[Students must be in the final
year of the respective degree/diploma in order to be
eligible, except for students of MCA, who can write the E,
I or D-level examination. Post-graduate students may apply
for any level for which they are eligible.]]>
  </BODY>
</REPLY>
```

Fig. 3 - QRR snippet

The part inside the QUESTION tag indicates the question and the part inside the BODY tag indicates the response (of some faculty) to the question. The WORD tag indicates the important words for the response. So whenever a new query comes, it is broken into useful words and those words are matched against the WORD tag. If the number of matches is above the threshold limit, defined in the MIN-MATCH tag, then the response is considered suitable and the same is forwarded to the student.

c) If no suitable response is obtained from the QRR then Sandesh forwards the query to the faculty after adding it to its Pending list. 'Fig. 4' shows the structure of the Pending list

```
<PENDING>
  <ID val="NSKJPTYRIZJTNMNGSUMJJHKZHG"/>
  <ADDRESS val="APARNA@NCST.ERNET.IN"/>
  <SUBJECT val="Path"/>
  <QUESTION>
    <![CDATA[In my Graduation I have done BCA (Bachelor
of Computer Applications ) from Indore Univ & Post
Graduation in Business Administration ( PGDBA ) from ITM
Kharghar with sp. in Marketing & IT. Currently I am
associated with TechNova Imaging Systems on Profile of IT
Infrastructure Management. I hereby want to know: Am I
eligible for the above mention course in Project Mgt, Course
Time Table and Fees & Payment Mode]]>
  </QUESTION>
</PENDING>
```

Fig. 4 - Pending List snippet

This list will help Sandesh to send automatic reminders to the faculty.

VI. CONCLUSION

The core part of Sandesh is complete and is planned to be used for our internal requirement first. We have evaluated Sandesh's response in terms of accuracy using data from queries encountered in our diploma programmes. Overall we find the response adequate. However, further test are in progress with a larger corpus.

As a part of future work, we plan to implement the following features in the Sandesh:

- Searching for responses on the web from a predefined list of sites.
- Managing multiple sets of responses as a way to address handling students with different learning pace.
- Providing facility to the users to update the QRR and Command files through the system.
- Automatic identification of faculty with the help of keywords and configuration files. Currently Sandesh assumes a standard faculty account.
- Handling emails with attachments. For mails with fixed subject lines we may want to store the attachments of the mails in a certain directory.

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A Constructive Learning Framework for Language Tutoring

Archana Rane, M Sasikumar

Education Technology Unit

C-DAC Mumbai

Sector 7, CBD Belapur

Navi Mumbai, India - 400 614

{archana,sasi}@cdacmumbai.in

Abstract—There is a lot of interest in second language learning in formal as well as colloquial form. With the advent of Internet and computer technology there is more and more demand for computer-based tutoring systems for language learning. However, not all computer-based tutoring systems available address the pedagogy component in language learning. There is a need for a language tutoring system which not only uses technology to deliver content but also applies pedagogical component for effective personalized instruction. We have designed and developed a constructive learning framework for language tutoring. The framework enables personalized instruction by adapting itself to the knowledge level of the student. Various pedagogical principles for second language learning are incorporated in the system. Using the framework we have implemented a tutor for the Indian language Marathi. The framework can be adapted to develop tutoring systems for various languages.

I. INTRODUCTION

The interest in learning natural language is increasing, given the large number and variety of languages and the increasingly global nature of life. Some of the reasons that motivate people to learn a new language (here we refer to a second language) include: befriending with a location and people around, getting well-versed in one's mother tongue, understanding culture of a particular area, tourism, etc.

There are various approaches available for language learning. Traditional approaches for language learning include resources such as books, magazines, etc and private courses where a particular language is taught to aspirants by a native expert. Such courses normally start by teaching script of the language and pronunciations of syllables. The course then proceeds to grammar, introduction of pre-defined subset of vocabulary, common expressions and simple everyday conversations to conversations in specific domains.

The traditional approach, however, does not adequately meet demands such as on demand learning, anytime learning and on-demand learning. Web-based educational systems, which to a large extent overcome the challenges posed by traditional classroom learning and textbook learning, are becoming increasingly popular. These systems exploit various ad-

vantages of the Internet technologies such as anytime anywhere access, sharing of learning material and online collaboration. One of the major charms of e-learning is to provide any-pace learning. This necessitates the system to adapt the pace – teaching style, level of detail of instruction, etc – of presenting course content based on the student's current profile. Intelligent Tutoring Systems (ITS) [1] make use of adaptive technologies to bring in aspects of a human-teacher delivering personalized tutoring to a student, into online computer-based learning environments.

The use of a web-based educational system (whether intelligent or not) for language learning has been a major area of research and has evolved into a full discipline known as Computer Assisted Language Learning (CALL) [7]. Language pedagogy has a marked significance in the technology-pedagogy co-operation of a Web-based CALL. Some of the fundamental pedagogical principles of language learning [6] include practice, learner orientation and motivation, changing role of teacher, iterative learning, situation-based learning, etc. Much of the concerns in pedagogical aspects come from the theory of learning. Constructive Learning Environments (CLE), one of the emerging trends in Virtual Learning Environments, is based on one the constructivist learning theory [10].

In this paper, we propose a constructive learning framework for language tutoring. The system would be web-based for wider and easier accessibility and would use a rich set of pedagogical ideas in a constructive learning approach to enable the learner to learn the language for use in day to day situations. The focus is not on deep formal study of the language.

The next section describes some of the related work from literature, on CLE, CALL, ITS (specifically in the area of language learning). Section III describes our approach to build the constructive framework for language tutoring. The architecture of the system is discussed in Section IV. Section VI summarizes the current status of the system and looks at future directions.

II. RELATED WORK

Our proposed system builds on work in areas of Computer Assisted Language Learning (CALL), Intelligent Tutoring Systems (ITS), Intelligent Computer Assisted Language Learning (ICALL) and Constructive Learning Environments (CLEs). This section touches the key aspects of each of these.

A. Computer Assisted Language Learning (CALL)

A number of paradigms have been proposed for teaching natural languages using a computer. The use of computers and associated technologies to facilitate language learning is known as Computer Assisted Language Learning (CALL) [7]. Based on the teaching methodology, CALL systems can be classified into [5]:

- i) Grammar oriented CALL system, where the target language is taught using grammatical components and structure as the base.
- ii) Situation based CALL system, which attempts to let the learner learn the language through its use in various commonly occurring practical situations such as at a shop, post office, etc.
- iii) Immersion based CALL System, which borrows from the way children learn their first language and avoids the use of a supporting language for instruction.
- iv) Collaborative CALL System, which represents and guides the interaction between the student and the system as an interaction between a small group of learners.

B. Intelligent Tutoring System (ITS)

In a traditional classroom setup, a teacher employs various mechanisms to sustain the student's attention, and provides appropriate guidance to the student based on his weaknesses and strengths in a particular subject. Though web-based educational systems have a lot of advantages, they still lack the presence of a teacher. ITSs attempt to simulate a teacher, who guides the student's lesson flow, based on the student's level of understanding in the subject. Basically the approach is to record expertise of a teacher in the subject and the understanding of the student in the subject, so as to deliver an effective personalized instruction.

In order to give intelligent instructional feedback and guidance to a particular student, ITSs typically rely on three types of knowledge, organized into separate modules [1]:

- i) Expert Model: This model represents the domain knowledge or expertise in the subject being taught, possibly derived over years of experience in that particular domain.
- ii) Student Model: This model represents the understanding of the student in the subject, i.e., what the student knows and what he does not know.
- iii) Instruction Model: This model, which is sometimes called the pedagogy module, consists of teaching strategies and the essential instructions. Various teaching strategies are adapted by this module to suit the student's needs.

C. Constructive Learning Environments (CLE)

The early models of learning were of a behaviorist nature.

With increased understanding of how humans learn, this model gave way to what came to be known as cognitivist learning theory. Ideas such as learner model and strategies of instruction were introduced at this stage. The most popular model today is a refinement of cognitivism, named as constructivism. The basic premise of constructivism is that learning is individual, in that learning takes place when a learner revises his current mental model of the domain. Neither the existing model nor the nature of revision is directly under the control of the teacher. The task of the teacher and the instruction is to guide this learning process, effectively. Facilitating the learner to experiment with his current level of understanding of the domain, and giving him constructive feedback along the way is the major theme of constructive approaches to learning.

CLEs are learning environments built on a constructivist learning model. These systems provide effective playing grounds for learners to try out what they learn and get constructive feedback. The playing ground can take a variety of forms from the simple descriptive problem solving to simulated building of a device.

Examples of such CLEs are the chemistry lab simulation [<http://www.chemcollective.org/vlab/vlab.php>] and the practice environments provided in the www.w3schools.com for learning scripting languages like HTML, DHTML, Javascript, etc. CLEs hold substantial promise of taking e-learning to a wider audience and increasing its effectiveness, and hence is an important field in instruction design [11].

CLE is an active area of research work in C-DAC Mumbai. An early work was in creating an intelligent tutoring system, Acharya [8], for teaching SQL.

D. Intelligent Computer Assisted Language Learning (ICALL)

Traditional CALL systems lack the intelligence component which would adapt instructions to a student based on his knowledge level in the language and to analyze student responses in depth to provide effective feedback. ICALL (Intelligent Computer Assisted Language Learning) system [4], which emerged to overcome this drawback of the traditional CALL systems, is a combination of ITS and traditional CALL, often following a constructivist approach. ICALL characterizes language teaching and learning as essentially a problem solving process, where the learner seeks to master a task or goal. ICALL programs, in contrast to traditional CALLs, can extract the learner's intentions by taking as input the learner's interactions with the system. This knowledge is then used to provide feedback and to structure further instructional activities. Three general features of ICALL systems can be identified that serve to distinguish these systems from more traditional CALL programs [4]: a problem solving approach to teaching and learning; the dynamic nature of processing; and explicit representation of domain knowledge.

E. Language Tutoring in Indian Languages

Tutoring systems available for Indian languages are very

few. We studied two such systems in detail viz. Marathi Mitra and LILA.

Marathi Mitra [<http://www.marathimitra.com>] is a web-based system which attempts to teach spoken “Marathi” language, using English as supporting language of instruction. It introduces a separate pronunciation key for Marathi. The course content covers vocabulary in various categories (general and advanced), basic grammar, day to day expressions and a few conversations. Almost all the language constructs have associated audio files.

The Learn Indian Language through Artificial Intelligence (LILA) is an Intelligent Tutoring System for Hindi [<http://lilapp.cdac.in>]. The courses included in the LILA series are based on Hindi Prabodh, Praveen, and Pragya syllabus, being conducted through classroom teaching and distance education by Department of Official Language (DOL), Government of India. The system attempts to teach Hindi language, in written as well as spoken form while taking into account pedagogical issues as well. For example, a student can attempt some lessons only after completing prerequisite lessons. The course content is classified into sections which introduce alphabets, vocabulary and then sentence constructs. All of the constructs are supported with language scripts, images, audio and video at places.

All the CALL systems we studied share common features like rich set of vocabulary, audio for pronunciation, script of the target language, basic grammatical constructs, expressions, conversations, etc. However most of them lack intelligence component, that should ideally guide the student to follow a sequence, suggesting what they should do next with the current level of understanding and why. These are quite weak from a constructivist point of view relying mostly on traditional teaching model with rote unguided practice sessions.

III. APPROACH

We propose a framework to teach a language in its conversational form taking into account the issues that are not yet fully addressed by the available language tutoring systems. The system is based on constructivist theory of learning. Each learner absorbs the instruction depending on his existing mental model that includes his profile, learning style, current level of understanding in the system and constructs a revised mental model. In addition to teaching the language, the system also acts as a teacher who guides the flow of the course.

The framework covers basic vocabulary and construction of simple and compound sentences, thus enabling the learner to converse fairly well in common places like bank, post office, etc. The system aims to make the participant comfortable in the target language rather than mastering the literature in the same. We have also tried to incorporate a number of pedagogical ideas keeping in mind challenges of retaining motivation, attention and focus for a typical e-learner.

A. Lesson Structure

The course content is presented in the form of different lessons. Each lesson in turn consists of various subtopics

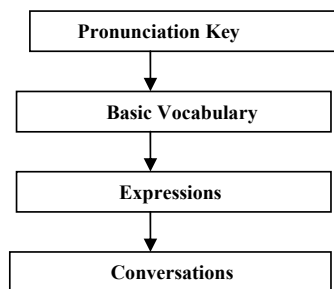


Fig. 1. Default Sequencing of Lessons

and/or evaluation sessions. The sequencing is based on the information set by the faculty. The default sequencing of lessons is illustrated in Fig. 1. As shown in Fig. 1, after an introductory lesson on the pronunciation key for the language, there is a lesson to introduce basic vocabulary from various categories followed by a lesson on expressions concluding with full-fledged conversations.

The framework facilitates change of lesson sequence as well as addition of new lessons as required. At the end of each lesson there is a final quiz for evaluation. The students can get familiar with the format and methodology of the final quiz by attempting the corresponding sample quiz. The content organization in a lesson and the quiz methodology i.e. nature of questions etc is based on the pedagogy model chosen for particular lesson. The student is deemed to have completed a lesson only when he clears the associated quiz. He clears the quiz if he scores more than the specified threshold of marks.

The framework allows each construct being introduced to be associated with one or more images, audio file(s) and pronunciation key. While the images are used to depict the language construct in a situated context, the associated audio clip and pronunciation key is used to pronounce the language construct in the target language. At places the images can also be supplemented with short video clips to demonstrate certain items in the vocabulary, particularly for verbs.

The system ensures step by step learning by forcing the student to learn the fundamental constructs before moving on to advanced level constructs. For example, before moving on to “Expressions” lesson, the system makes sure that the student has a fair understanding of “Basic Vocabulary” in the target language. This information is obtained from the student’s performance in quiz session on “Basic Vocabulary”.

In the “Vocabulary lesson”, wherever relevant, multiple images are used to depict the word it represents, to reduce the ambiguity. Sometimes a single image may not clearly indicate what concept it represents. For example, we display image of a “Pen” for some word in the target language which means a “Pen”. Now, it is not very clear with a single image display, whether the word this image is representing refers to the color of the image, shape of the image or the object that the image illustrates, thus leading to ambiguity. However if we display multiple images in the similar context, the exact meaning of

the word that these images represent becomes evident.

B. ITS Component

The framework models the three modules of a typical ITS system as follows:

i) Expert Module: This module here represents the domain knowledge (set of vocabulary, expressions, scripts, audios, etc along with their dependencies and other parameters) of the target language.

ii) Student Module: This module is concerned with updating and reasoning with the student model. The student model represents the student's current understanding of the subject. The level of understanding of the student will be determined based on his performance (i.e. marks, attempts) in the respective evaluation sessions. Suppose a student scores less than a specified threshold of marks in the evaluation sessions of lesson "A". He will not be allowed to visit any lesson, for which "A" is a prerequisite, till he clears the evaluation session for "A".

iii) Instructor Module: This module in the system represents the instructional knowledge, by selecting and sequencing the lessons and associated materials/resources and incorporating learning strategies. The instructor module selects the lessons to be displayed to a particular student based on the corresponding student module.

C. Pedagogy

The framework addresses a number of pedagogical principles for second language learning as follows:

i) Iterative Learning: An iterative practice phase of the course material is necessary for learning in terms of long-term memory. In vocabulary lesson, for example, he can listen to the audio clip multiple times till he gets comfortable with the corresponding construct and then move to the next or previous construct or even choose a construct randomly. He can also revisit any given example construct multiple times.

ii) Learner Focus: Keeping in mind the low attention span of the online student, language constructs and vocabulary are presented to the student one at a time rather than presenting all of them at once. It helps him to focus on a single construct rather than many constructs at a time.

iii) Learner Motivation: As specified earlier, the system adapts itself to the level of understanding of the student in the course. This personalized attention to a student plays an effective role in his motivation and receptiveness to learning.

iv) Situation-based Learning: A learner being immersed in a particular situation leads to effective grasping of language constructs, compared to formal abstract teaching. Our system immerses the student in common situations/places such as in a post office, bank, etc, while teaching expressions and conversations, thus attempting to let the learner learn the language through its practical use at general places or situations.





Some special strategies have been employed by the framework to facilitate effective learning. Without a syntax based approach, teaching a learner how to form expressions is a challenging task. We do not want the student to memorize

expression as in the case of words. The idea instead is to help him see the underlying structure of the expression that he learns to form such expressions on his own. This is done by presenting number of sets of variants of the given expression. Each set is called a cluster, and varies one or more words in the "master" expression. For example, consider an expression "It will take ten days to reach." A cluster of this expression construct may vary the word "ten" and the resulting expressions belonging to this cluster could be like "It will take twenty days to reach", "It will take five days to reach" and so on. Another cluster would be a set of expressions varying the word "days" in the master expression. The english versions of expressions belonging to this cluster would be "It will take ten months to reach", "It will take ten minutes to reach" and so on. An expression may have one or more of such clusters and corresponding expressions in the target language. Thus by providing variants of a single "master" expression, the system attempts to let the learner master an expression construct rather than learn just a particular expression.

Also for better understanding of pronunciation of each word in the expression, each expression is also accompanied by a slow speed version of audio clip.

D. Navigation and Learner Support

A good navigational support is necessary for the student to feel comfortable in an e-learning environment. Our system represents the course content with a navigation mechanism that guides the student through the course. It provides visual indication of where the student is currently in the concept map of the course, an ability to visit other lessons in the course, and indications of what he can do next.

The menu on the left side of the screen (see Fig. 4) consisting of the list of topics and its navigation mechanism is based on the intuitive traffic light model [9]. A Red cross icon () signifies the sessions that the student is not currently eligible for, Green tick icon () signifies the sessions that the student is currently eligible for and Blue flag icon () signifies sessions that the student has already completed. In addition to the above icons, an arrow icon () indicates the lesson he is currently viewing.

IV. SYSTEM ARCHITECTURE

The system follows a 3-tiered architecture, with separate layers for presentation logic, business logic and data store. The system also adheres to the Model View Controller (MVC) architecture [<http://www.javaworld.com/javaworld/jw-12-1999/jw-12-ssj-jspmvc.html>]. This not only makes the system modular, but also facilitates adaptation to changes in the system. For example, if we want to switch to some other database, changes will be limited only to the data storage tier. The business logic tier and presentation logic tier would not see any changes. In terms of the MVC model, "View" and "Controller" need not change as long as the "Model" used to represent the data remains the same.

A. Module Design

Based on the functionality, we divided the system into various logical modules (see Fig. 2). Each module puts together a set of related functions and interfaces with the rest of the system as a single logical chunk. In the 3-tiered architecture of the system, these modules sit in the business logic tier. Following are the modules in the system, with a brief description of the functionality they encapsulate:

- i) Authentication Module: This module authenticates the users logged in against the user details available in the system.
- ii) Instruction Module: This module manages the lesson sequencing as well as pre-requisites for each lesson. This module gets the student's current understanding level from the Student Module. Accordingly, it invokes appropriate lesson from the Lessons Module.
- iii) Student Module: This module manages the student details such as his login details and his current understanding of the subject.
- iv) Lessons Module: This is a cluster of modules, each representing a particular lesson. By default, the framework supports four lesson modules viz. "Pronunciation Key" module, "Basic Vocabulary" module, "Expressions" module and "Conversations" module.
- v) Examination Module: This module encapsulates the functionality of the evaluation component of all the lessons, such as fetching quiz data, passing it for display, evaluating a student's attempt for a particular quiz and recording the student score. It also passes the student score to the Student Module.

B. Implementation

The system is implemented using JSP, servlets and JavaBeans (see Fig. 3) and runs on Tomcat server. The user interface to the application is handled by JSPs. Servlets and JSPs interact with the JavaBeans. JavaBeans represent the data residing on the server.

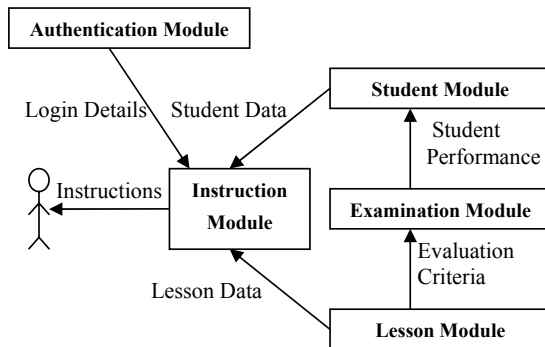


Fig. 2 Architecture of the System

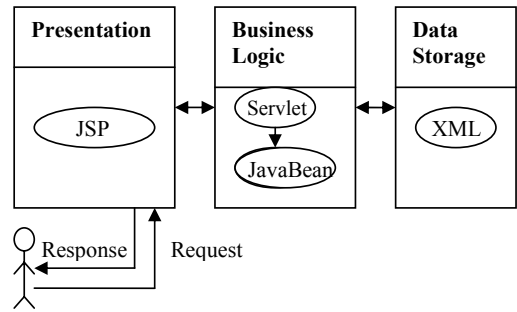


Fig. 3 Implementation as 3-Tier Model

We have used XML for structuring and holding data. Use of XML makes the data more readable, extendable and makes it easier to express metadata. It also allows easy interchange of data. Depending on the type of our data model can be classified into Lesson Data, Instruction Data, and Student Data. Each type of data is organized in one or more XML files.

C. Extending the framework

Adding new phases of learning (like grammar, advanced vocabulary, etc) can be done by manipulating the "Lesson Data" and making corresponding changes in the "Instruction Data".

Data storage and representation is designed and structured in a generic fashion so that it can be easily extendable as well as represent data of other languages. The native Unicode support in XML facilitates holding/displaying data of various languages in their respective scripts. So implementing a tutor for other Indian languages would require just changing the Lesson Data as long as English is the language of instruction.

V. CASESTUDY

Using this framework we have implemented a tutor for an Indian language, Marathi (see Fig. 3). The tutor intends to teach Marathi in its colloquial form. We use the default lessons sequencing provided by the framework. After an introductory lesson on the pronunciation key for Marathi, there is a lesson to introduce basic vocabulary from various categories followed by a lesson on expressions concluding with full-fledged conversation. As of now, there are about 15 different categories in "Basic Vocabulary" lesson (like direction, anatomy, etc) covering over 200 along with associated audio files and images wherever required. Expressions are categorized in general categories like "Business", "general expressions", etc. Each category is further classified into 2-3 subcategories. Each expression subcategory consists of around 10 expressions each. Most of the expressions consist of 2-3 clusters, the cluster in turn consisting of 4-5 variants of the original expressions. There is a question bank of around 30-40 questions for each quiz in a particular lesson. The "Conversations" lesson consists of 5-6 full-fledged conversations.

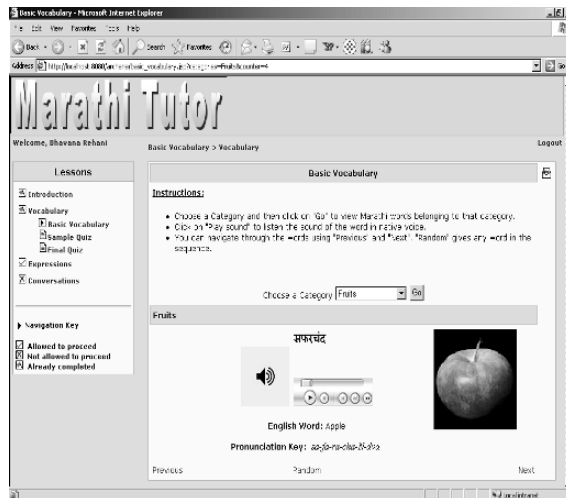


Fig. 4 Tutor for Marathi

VI. CONCLUSION AND FUTURE WORK

We discussed various issues in computer-based language tutoring and proposed a constructive framework for language tutoring. A number of pedagogical ideas in the area of language learning have also been incorporated. As a case study we implemented a tutor for teaching Indian language Marathi, in colloquial form.

We are planning to do a formal evaluation of the system by making it (tutor for Marathi) for use among a controlled set of audience. This would also give valuable feedback on the effectiveness of the pedagogical principles used, in learning and better understanding of the system. Once we get inputs from these users we will be releasing the system open over the web for general public. Later, we also plan evaluation mechanisms within the system to get continuous feedback on the effectiveness of each lesson.

The framework is being improved in many dimensions for a richer and more comprehensive learning experience. We plan to extend the framework to support the concept of pre-test, which the student can appear before going through the course content. Based on the performance of the student in the pre-test, the system would allow direct entry to specific lessons. Currently the default extent of the lessons is upto conversation level. We plan to take it further by incorporating appropriate pedagogy ideas for effective instruction and investigating

various pedagogy schemes for the same. Instruction module can be extended to give more intuitive feedback to the student after every exam, which will help him identify his weak areas in the course.

ACKNOWLEDGMENT

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Assessing Critical Thinking in STEM and Beyond

Barry Stein, Ada Haynes, Michael Redding, Theresa Ennis, and Misty Cecil
Tennessee Technological University

Abstract- This paper reports the latest findings of a project to refine the CAT© instrument, a new interdisciplinary assessment tool for evaluating students' critical thinking skills. Tennessee Technological University partnered with six other institutions across the U.S. (University of Texas, University of Colorado, University of Washington, University of Hawaii, University of Southern Maine, and Howard University) to evaluate and refine the CAT instrument. The results of this project reveal the CAT instrument has high face validity when evaluated by a broad spectrum of faculty across the U.S. in STEM and non-STEM disciplines, has good criterion validity when compared to other instruments that measure critical thinking and intellectual performance, has good reliability, and good construct validity using expert evaluation in the area of learning sciences.¹

INTRODUCTION

There is little question that as a result of an increasingly technological and information driven society the ability to think critically has become a cornerstone of both workplace development and effective educational programs. Critical thinking is central to both the National Science Standards [1] and the National Educational Technology Standards [2]. Derek Bok [3] notes that over ninety percent of faculty in the U.S. feel that critical thinking is the most important goal of an undergraduate education. Increasingly, the importance of critical thinking/problem solving skills in the workplace is also being recognized. For example Halpern [4] argues, "virtually every business or industry position that involves responsibility and action in the face of uncertainty would benefit if the people filling that position obtained a high level of the ability to think critically". A recent Tennessee Technological University (TTU) survey of employers revealed that skills typically associated with critical thinking represented four out of the top five skills considered most important [5]. Similarly, a recent CNN poll of employers found critical thinking is one of the top five essential skills in business that employers look for in potential job candidates [6].

Despite the central importance of critical thinking in the workplace and education, existing assessment tools are plagued by problems related to validity, reliability, and cultural fairness [7]. According to Bransford, Brown, and Cocking [8] "a challenge for the learning sciences is to provide a theoretical framework that links assessment practices to learning theory" (142).

Tennessee Technological University (TTU) has explored and tested a variety of instruments for assessing critical thinking and has spent six years developing the Critical thinking Assessment Test (CAT) that overcomes many of the weak-

nesses of existing instruments. TTU's approach has been to involve faculty in the identification of a core set of skills they believe to be an important part of critical thinking across all disciplines. An interdisciplinary team that included both STEM (Science, Technology, Engineering, and Math) and non-STEM faculty worked together with a member of the faculty who had extensive research and teaching experience in the area of critical thinking and problem solving to develop the test. The initial CAT test demonstrated high face validity and high criterion validity when correlated with other widely used measures of critical thinking and achievement.

The current paper examines work that TTU conducted in cooperation a diverse set of six schools nationwide to further test and refine this instrument. Through these efforts a test has been developed that has good face validity, good construct validity, good reliability, and that is culturally fair. Pellegrino, Chudowsky and Glaser [9] note that in addition to face validity, assessment instruments need to be developed based upon principles of learning and cognition. To meet this standard, preeminent theoreticians and educators in the area of learning sciences participated in the current project and helped refine the instrument.

The CAT instrument is relatively unique in that it is one of just a few critical thinking assessment tools available that uses short answer essay responses to assess critical thinking. While subjective tests can be plagued by problems of scoring reliability, this has not been the case with the CAT instrument. Indeed, there appear to be several important advantages of using essay tests to assess critical thinking. Specifically, many authentic real-world situations that require critical thinking and problem solving do not have a simple answer or a simple set of alternatives from which to choose the best answer. Providing such alternatives on a test can frequently dramatically alter the original problem and greatly simplify the complexity of the task. Many would also argue that the reasons given to support a specific answer are often as important as the answer itself. The short answer essay format allows the CAT instrument to examine such reasoning and thought patterns. Some may consider the fact that the CAT instrument uses an institution's own faculty to score the short answer essay questions a shortcoming. TTU has found that using faculty graders is the best way to make faculty aware of student deficiencies in the area of critical thinking and to motivate faculty to consider changes in pedagogy that might improve students' critical thinking skills.

METHOD

Six institutions from diverse geographical regions across the U.S. with different missions and student bodies participated in the project (the University of Texas, the University of

¹ Partial support for this work was provided by the National Science Foundation's CCLI Program under grant 0404911.

Colorado, the University of Washington, the University of Hawaii, the University of Southern Maine, and Howard University). Each institution administered the CAT instrument to a sample of approximately 100 upper division students across STEM and non-STEM disciplines. Students were paid to participate in the testing.

Materials

The CAT instrument is a 15 question test with mostly short answer essay questions. The questions were specifically designed to evaluate the skill areas identified in Table 1. The questions explore various real-world situations that students find intrinsically interesting. A significant part of the test is devoted to solving a complex real-world problem that involves learning and applying new information – a testing practice sometimes referred to as dynamic assessment. The complex problem is designed to mimic many aspects of real-world problem solving. For example, in addition to solving a complex problem, decisions must be made about the types of articles that would be relevant to the solution of the problem as well as deciding how the solution to the problem might change if certain aspects of the problem situation were altered.

Testing Procedure

Students were tested in groups. The testing instrument was provided in booklet form with a package of additional readings. Each student was asked to complete all questions in the instrument, and was given up to 60 minutes to complete the task. There was seldom a situation where any student did not have sufficient time to complete the test.

Scoring Procedure

A full day scoring workshop was held at each institution to assess student performance using a detailed scoring guide developed for the CAT instrument. Approximately 10-12 faculty from both STEM and non-STEM disciplines participated in the scoring workshop at each institution. Faculty were paid to participate in the scoring process.

During the scoring sessions, faculty received training on using the scoring guide immediately before each question on the test was scored. Each student’s response to that question was then scored independently by two faculty members. If there was not agreement between the first two scorers, the question was scored by a third faculty member. The final score for each question was either the common score assigned by two graders or, in the case of three different scores, the average of the three different scores. This process was repeated for each question on the test. Tests were frequently redistributed to ensure that each faculty would see as many different tests as possible.

Faculty participants in the scoring workshop also completed several surveys after they finished scoring the tests. These surveys examined the face validity of the questions on the CAT instrument and whether the skills assessed by the CAT instrument were valid components of critical thinking (see Table 1).

RESULTS

Evaluation of Skill Areas Targeted by the CAT Instrument

All of the skill areas targeted by the CAT instrument were perceived as valid components of critical thinking by most faculty who participated in the scoring workshops. The area with least agreement (79.4%) concerned using mathematical skills to solve a complex real-world problem (see fig. 1). The latter finding is mostly due to lower ratings by non-STEM faculty in some disciplines.

Evaluation of Question Face Validity

Faculty who participated in the scoring workshops were asked to evaluate the face validity of each question in the CAT instrument as a measure of critical thinking. Most faculty felt that the questions included on the CAT instrument were valid

TABLE 1
SKILL AREAS ASSESSED BY THE CAT INSTRUMENT

Separate factual information from inferences that might be used to interpret those facts.
Identify inappropriate conclusions.
Understand the limitations of correlational data.
Identify evidence that might support or contradict a hypothesis.
Identify new information that is needed to draw conclusions.
Separate relevant from irrelevant information when solving a problem.
Learn and understand complex relationships in an unfamiliar domain.
Interpret numerical relationships in graphs and separate those relationships from inferences.
Use mathematical skills in the context of solving a larger real-world problem.
Analyze and integrate information from separate sources to solve a complex problem.
Recognize how new information might change the solution to a problem.
Communicate critical analyses and problem solutions effectively.

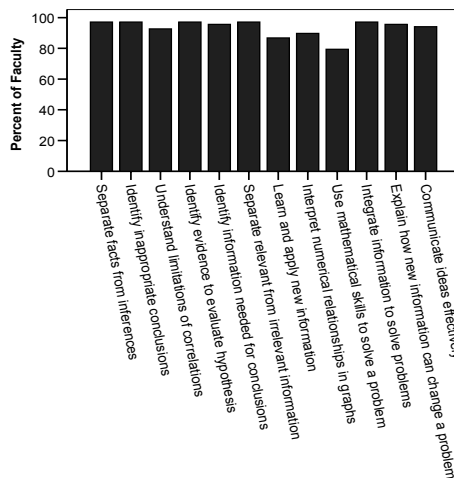


Fig 1. Percent of Faculty that Identify Areas Targeted by CAT as Valid Components of Critical Thinking

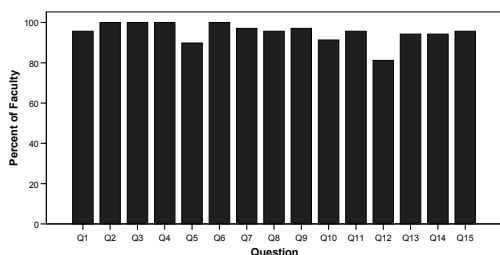


Fig. 2. Percent of Faculty Indicating Each Question Measures a Valid Component of Critical Thinking

measures of critical thinking (see fig. 2). The question with the lowest overall support (81.2%) involved using a mathematical calculation that was needed to help solve a complex real-world problem.

In addition to the quantitative survey data discussed above, qualitative data were collected from the local testing coordinators and the faculty scorers, as well. The comments received from both faculty scorers and the local testing coordinators were overwhelmingly positive. Many faculty felt the test was very useful for identifying student weaknesses, and others were interested in using the test within their disciplines to help explore ways of making program improvements.

Distribution of Student Scores and Internal Consistency

Fig. 3 shows the distribution of student scores (raw) on the CAT instrument against the normal curve. Scores ranged from a low of 6 to a high of 36.3. There was no evidence of a floor effect or a ceiling effect (lowest possible score = 0, highest possible score = 40).

The internal consistency of the questions was also examined and found to be reasonably high for an instrument of this type, $\alpha = 0.695$.

Correlation with other Measures of Student Performance

Performance on the CAT instrument has been correlated at various times with other measures of student performance including cumulative grade-point average (GPA), entering

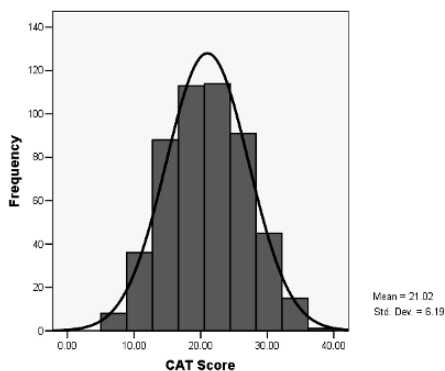


Fig. 3. Distribution of Student Scores

SAT or ACT scores, and performance on several other tests that might measure skills associated with critical thinking; including the Academic Profile (AP) and the California Critical Thinking Skills Test (CCTST). The correlations from previous work appear in Table 2, while the correlations from the current project appear in Table 3. The correlations provide support for the criterion validity of the CAT instrument. At the same time, the magnitude of the correlations also indicates that the CAT instrument measures something different than the other assessment tools.

Scoring Reliability

Scoring reliability is often a problem for essay type tests. However, extensive work has been done to refine the scoring rubric for this test to improve scoring reliability. The reliability of scoring was evaluated by examining scores assigned by faculty grader one and faculty grader two on each question. The average reliability of scoring across questions was 0.82.

Preliminary Analysis of Cultural Fairness

The CAT instrument in its current form is designed to assess critical thinking skills of students in U.S. colleges and universities. Nonetheless, it is still important to evaluate whether the instrument has bias against any of the subgroups within this population. Although more extensive analyses of any possible ethnic/racial/gender bias in the CAT instrument are planned, preliminary analyses of available data provide encouraging results. Multiple regression analyses reveal that once the effects of entering SAT score and GPA are taken into account, none of the predictors related to gender, ethnic background, or racial group are significant predictors of overall CAT performance.

CONCLUSION

There have been several significant outcomes of this project. For example, this project has been able to find a relatively high level of agreement across a diverse group of faculty from diverse disciplines about what skills might be considered valid components of critical thinking. The project has also found high levels of support for the face validity of questions in the instrument. There have been few attempts to establish such common ground among the disciplines in higher education about what constitutes "critical thinking."

The project has also been successful in demonstrating the criterion validity of the CAT instrument when compared to

TABLE 2
CORRELATIONS FROM PREVIOUS WORK

	ACT	AP	CCTST
CAT	0.599*	0.558*	0.645*

* correlations significant, $p < .01$

TABLE 3
CORRELATIONS IN CURRENT STUDY

	SAT	GPA
CAT	0.527 *	0.345*

* correlations significant, $p < .01$

other measures of academic performance. Finally, the project has managed to circumvent a major problem for essay type tests by providing relatively high rates of scoring reliability with faculty who had no prior experience grading this type of exam.

The refinement of the CAT instrument is also significant for another reason. The CAT instrument is one of the few interdisciplinary assessment instruments available that also provides an opportunity for faculty development. By participating in the scoring process, faculty become aware of their students' deficiencies and can begin to explore modifications in teaching methods that might address these weaknesses. This becomes increasingly important as accrediting agencies such as the Accreditation Board of Engineering and Technology (ABET) increase their focus on aspects of critical thinking such as life-long learning skills [10].

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The TEUTATES-Project: Tablet-PCs in Modern Physics Education

N. Dahlmann, S. Jeschke, O. Pfeiffer, H. Scheel, C. Thomsen
Technische Universität Berlin
Department of Mathematics and Natural Sciences
Center for Multimedia in Education and Research
Straße des 17. Juni 136, 10625 Berlin, Germany

Abstract— The overall objective of the TEUTATES approach is to implement a flexible mobile learning concept for a modern physics education at universities, focusing on enhanced access to a broad variety of experiments. Within a blended learning concept, Tablet-PCs allow an extended experimental part of the education right from the beginning. Different types of experiments – remote and virtual – are introduced. Executed within web-interfaces, experiments can be implemented and accessed regardless of the location of the laboratory and the experimenter. Additionally, experiments can be performed which otherwise would not be accessible for reasons of expense, security, or availability.

Students work individually or in small groups, designing and executing different types and realizations of experiments including the investigation of the underlying theoretical models. Through its highly interactive approach, TEUTATES contributes to a modern pedagogy for university teaching which aims at creative thinking and high level learning, encouraging students to become active learners challenged by complex problems and situations, seeking collaboratively a variety of solutions. Information and Communication Technologies (ICT) are applied to learning purposes and modern pedagogies such as project-based learning, problem oriented learning, principles of non-linear learning, co-operative and cross-cultural learning.

Index Terms— tablet PCs, mobile teaching, remote experiments, virtual laboratories, physics education

I. INTRODUCTION

HANDS-ON-TRAINING has always been considered an essential part of the learning and teaching experience in natural and engineering sciences. However, presently the physics education of engineering students often suffers from a lack of comprehensive experimental components due to the large number of students in combination with limited experimental resources.

The integration of Tablet-PCs into physics education opens up new perspectives and allows to increase the experimental part of the education right from its start. Executed within web-interfaces, experiments can be implemented and accessed regardless of location of laboratory and experimenter. Additionally, experiments can be performed which otherwise would not have been accessible for reasons of expense, security, or availability.

Experiments of two principle kinds come into place: Virtual Laboratories are interactive, explorative learning tools, which emulate scientific hands-on experiments in virtual spaces by modeling and simulations, using the metaphor of a “real” scientific laboratory as a guiding line. They are capable of simulating various physical models and thus allow for investigation of experimental set-ups, which were infeasible in traditional laboratories. The complementary Remote Experiments are real experiments, remotely controlled from outside the laboratory by users anytime and anywhere.

However, enabling students to learn for experiments requires more than just offering the experimental setups: performing experiments includes taking notes, drawing setup sketches, writing protocols, analyzing the measured data, and visualizing the results. Here, within a blended learning concept, the potential of Tablet-PCs comes into place.



FIGURE 1: Physics class, projection of remote experiments in lecture hall.

II. EXPERIMENTS IN VIRTUAL AND REMOTE LABORATORIES

A. Remote Experiments

A Remote Experiment consists of two vital parts, namely the experiment itself, which is supposed to be conducted re-

motely, and the method being used to provide the necessary remote controls. For the Remote Experiments at the TU Berlin, National Instruments LABVIEW is used to control the hardware and collect the experimental data. LABVIEW also possesses a convenient web-interface, which enables the remote-experimenter to perform any necessary adjustments. In order to view and control the experiment, a freely available web browser plug-in has to be downloaded and installed. Due to the modular programming structure of LABVIEW, remote experiments can easily be combined or extended. Prof. C. Thomsen and research group [11] at the TU Berlin have already set up several remote experiments and several others are about to follow. A selection of these Remote Experiments is presented for illustration purposes:

- **Solar cells**

A solar – or photovoltaic – cell is a semiconductor device consisting of a p-n junction diode: two electrically contacted semiconductors, one positively doped, the other negatively, form a diode, which allows a current in one direction but not in the other. By illuminating the junction with visible light, free carriers will be generated and accumulated – thus, solar cells are capable of generating electrical energy. One important property of a solar cell is its “efficiency”, the ratio of the electrical-power output to the light-power input, as represented by its current-voltage (I/V) characteristics. Measuring the I/V -curves of a solar cell – in the dark and when illuminated – within a remote experiment enables the students to determine the efficiency of the solar cell. Running this experiment using different solar cells allows the investigation of material dependences (in Fig. 1 the solar cell experiment is demonstrated within a physics lecture).

- **Resonant circuit**

Resonance is an important phenomenon in technical applications. It can cause the damage of mechanical systems, e.g. bridges under the influence of strong winds or synchronous pedestrian walk (London Millennium Bridge), or can ensure the functioning of a system, as in an ordinary radio. Systems of electronic devices also show resonance phenomena: an LC-oscillator is a serial connection of an inductance and a capacitor. Between these devices, the electrical current alternates at a certain angular frequency. Applying a sinusoidal external voltage, the system will oscillate with the excitation frequency with a frequency-dependent amplitude. The frequency associated with the maximum amplitude is referred to as resonance frequency. Within our remote experiment, students can access an LC-Oscillator via the Internet to measure the amplitude in dependency of the stimulating frequency, thus determining the resonance frequency.

- **Magnetism & phase transitions**

The goal of the “magnetism” experiment is to gain insight into the phenomenon of phase transitions and the behavior of ferromagnetic substances [9]. A magnetic coil generates a magnetic field proportional to the current passed through it, controlled by the computer. The magnetic field in turn magnetizes a ferromagnetic core whose magnetization is measured by a Hall probe. A standard multimeter that provides a digital

output port then digitizes the measured value and transmits it back to the computer. By running the experiment, a student explores the non-linear dependency of the probes’ magnetization with respect to the external field. Thus, the student will become aware of the fact that ferromagnetic materials show a so-called “hysteresis loop”, a characteristic behavior for materials featuring phase transitions.

- **Raman scattering**

Raman scattering is a powerful light scattering technique used to diagnose the internal structure of solids, liquids and gases [7]. In a light scattering experiment, light of a known frequency and polarization is scattered off a sample. Most photons are elastically scattered, having the same wavelength as the incident photons (Rayleigh scattering). However, a small fraction of light is inelastically scattered at optical frequencies different from the frequency of the incident photons. This “Raman shift” is therefore an intrinsic property of the sample. Using a laser as light source, the Raman Remote Experiment allows students to collect Raman spectra of different samples, for example silicon and diamond, but also of carbon nanotubes and other solids or nanostructures. The design of the Remote Experiment allows changing the samples, modifying the polarization of the laser light and its intensity via remote control. Both parts of this experiment are depicted in Fig. 2 and 3.

- **Fourier transform spectrometer**

Fourier spectrometers are used to determine spectra [5]: light from a suitable source is split into two beams by a semi-transparent mirror, one is reflected off a fixed mirror and one off a moving mirror which introduces a time delay – in short, the Fourier transform spectrometer is just a Michelson interferometer with a movable mirror. The beams interfere, allowing the temporal coherence of the light to be measured at each different time delay setting. By measuring signal at many discrete positions of the moving mirror, the spectrum can be reconstructed using a Fourier transform of the temporal coherence of the light. Essential target of the experiment is the understanding of the Michelson interferometer and of interference. The second important attribute is the comprehension and use of Fourier transformation. For our remote experiment, a HeNe-laser will be used as light source enabling students to get a first hands-on experience with laser technology.

B. Virtual Laboratories

Virtual laboratories have revolutionized education and research as they allow a direct experimental access to abstract objects and concepts. The Virtual Laboratory VIDEOEASEL [8] (developed at the TU Berlin) is capable of simulating various models from the field of statistical mechanics, problems of thermodynamics, wave phenomena and chemical reactions. Measurements are performed by tools, freely plugged into the experiment by the user, allowing observation of magnetization, entropy, free energy or other measurable quantities during the experiment. When experiments of higher complexity are performed, the experimental results can be automatically exported into computer algebra systems (e.g. Maple or

Mathematica) for further analysis. To enhance co-operative work between students, or students and their teachers, VIDEOEASEL is able to support distributed measurement processes on the same experimental setup, including remote access from outside the university (for technical details see [3]). Again we highlight some selected experiments, which can be performed within the VIDEOEASEL lab:

- **Ising model & ferromagnetism**

The Ising model is a prominent lattice gas model used to investigate phase transitions and describe ferromagnetic behavior. A typical experiment is the measurement of the hysteresis loop: after starting the Ising simulation, the user attaches a probe (by selecting a region) to measure its magnetization (cf. Figure 4). The user interface now allows the variation of parameters of the model, for example the external field. By plotting magnetization over external field (cf. Fig. 8), one finds the desired hysteresis loop; by varying the temperature the phase transition of the model becomes observable. However, the Virtual Lab is also able to run experiments that are hardly feasible in reality: by changing the boundary conditions of the Ising model during runtime, one can investigate the impact of the boundary configuration on the spontaneous magnetization of the model and compare the behavior with the theoretical result of the Peierl's argument [10].

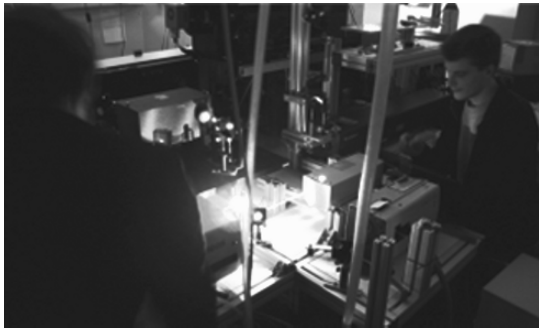


FIGURE 2: The remote experiment in the laboratory...



FIGURE 3: ... and the experimentors outside the lab, using Tablet-PCs to perform experiments

- **Irreversibility of time**

The dynamics of single molecules are difficult to investigate in “real” experiments but form an interesting field for

experiments in virtual laboratories: molecular dynamics simulate the trajectories of individual molecules by integrating the equations of motion, i.e., assuming Newtonian mechanics. This means, that in principle, time is reversible. Consider, for example, if one changed the sign of all molecular velocities at some point, then all molecules should end up at their initial positions after the appropriate number of time steps. This is clearly not the case in physical systems, where time is irreversible – a consequence of the second law of thermodynamics (cf. Fig. 5). This discrepancy – time reversibility for molecular dynamics, but irreversibility in real systems – is referred to as Loschmidt's paradox and can be observed within the VIDEOEASEL lab.

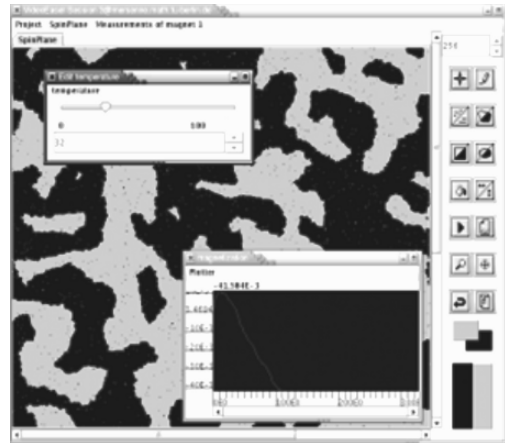


FIGURE 4: VIDEOEASEL Java Front-End for an experiment about the Ising model, measurement of the magnetisation

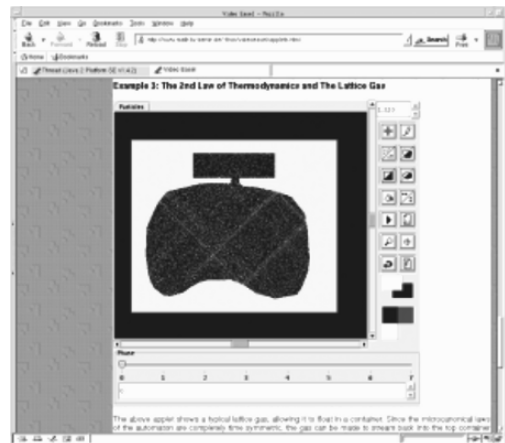


FIGURE 5: VIDEOEASEL Java-Applet integrated in a web-page; displaying an experiment on the 2nd Law of thermodynamics

- **Self-organization and periodic reactions**

Self-organization refers to a process in which the degree of internal organization of a system, normally an open system, increases automatically without being guided or managed by

an outside source. A prominent example is the so-called “Belousov-Zhabotinsky” reaction (cf. Fig. 6), a reaction-diffusion system showing oscillating – spatially and temporally – chemical reactions. A simulation experiment within a virtual lab allows the students to get a deep understanding of the fundamentals of self-organizing systems. Additionally, students may investigate the idea of self-organization in connection with the second law of thermodynamics (“ever-decreasing order”) gaining the insight that self-organization can only occur far away from thermodynamic equilibrium.

- **Discretization of partial differential equations**

In physics, partial differential equations as wave equation or heat equation play a very important role for a large number of applications (different types of wave propagation and heat conduction phenomena). Beyond a few “toy models” of fundamental and/or theoretical interest, most of these applications have to be solved numerically for realistic physical models for complexity reasons. Students have to learn how to describe those partial differential equations within numerical models. In particular, the appropriate discretization plays a fundamental role. Within virtual laboratories, partial differential equations can be modeled, and their impact can be investigated within different physical settings (cf. Fig. 7). Numerical effects resulting from discretization and rounding parameters become apparent.



FIGURE 6: VIDEOEASEL Java Front-End for an experiment about the Belousov-Zhabotinsky Reaction

C. Comparison

The examples described illustrate the typical setup of Remote Experiments as well as according experiments within a Virtual Laboratory. In both scenarios, the experimenter regulates a set of parameters controlling the experiment and interacting with it, e.g. by a motor, the magnetic field, or – in case of the Virtual Laboratory – also by manipulating the boundary conditions. Additionally, a set of measurement tools is provided collecting data from the running experiment, e.g. the temperature, the magnetization, a rotation frequency, the mechanical force, etc. Thus, the different approaches possess a number of similarities, but also enrich each other through their differences: on the one hand Remote Experiments allow for

the investigation of real objects including hands-on measurement experience, which does obviously not hold true for Virtual Laboratories. On the other hand, Virtual Laboratories are capable of mapping the complete process of constructing an experiment, whereas this kind of flexibility is clearly limited in remote experiments [2].

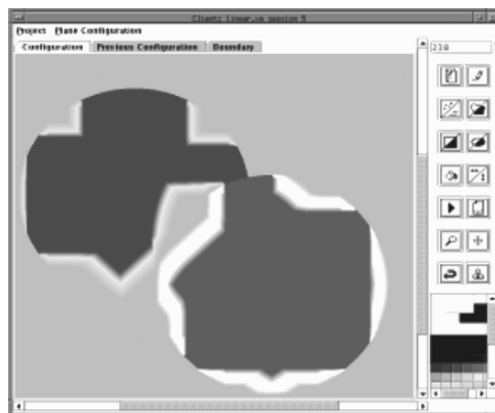


FIGURE 7: VIDEOEASEL Java Front-End for an experiment about the heat conduction equation

The accomplishment of experiments in eLearning scenarios can be measured in many aspects – ranging from the actual quantification of a physical measurement and operating experience with real experimental setups to the examination of the corresponding theoretical model – of the learning process in the academic education of natural and engineering scientists. Even though the two systems are not identical (which model is capable of exactly describing physical reality?) the combination of a remote and “real” experiment and a sound simulation supports the process of understanding in an outstanding manner which is vital for the learning and teaching process in natural sciences and engineering.

III. INTEGRATION OF TABLET-PCs & EXPECTED OUTCOMES

The usage of Tablet-PCs forms the basis of the TEUTATES project: preserving the advantages of traditional teaching methods in modern eLearning scenarios, TEUTATES enables training scenarios based on different types of remote and virtual experiments. However, while the TEUTATES approach is based on the metaphor of the traditional laboratory, it is enriched by a wide range of multimedia enhancements: students can note test protocols, including experimental setup sketches, tables and diagrams graphically on the Tablet-PC. They are enabled to complete their records by embedding external material, e.g. images from the web or interactive applets. Experimental results determined by other researchers can be included for the purpose of comparison and questioning of own results. In the future, through integration of handwriting recognition, computer algebra systems will be queried for their numeric or symbolic results and function plots. Students may even send queries to remote web services (CGI scripts) to running interactive simulations and visualizations

from arbitrary sources. Furthermore, modern synchronous and asynchronous communication and co-operation tools will come into place, transforming the traditional image of “isolated” laboratories into networked collaborative working environments for natural sciences.

Providing a steadily increasing number of remote and virtual experiments, continuously available to a broad target audience of students and teachers independently of physical location, the expected results can be summarized as follows:

- Students of all engineering fields will gain enhanced, comprehensive access to “hands-on”-experiments.
- The education of engineering students in the field of physics will be transformed from teacher-led to more contemporary student-centric learning scenarios.
- State-of-the-art computer algebra systems, numerical software packages, and visualization tools will become integral parts of modern sophisticated education for all fields of technological studies.
- Mobile learning and teaching scenarios will impact education, research and the organizational structures of the different fields of studies.
- Students will be supplied with the opportunity to get acquainted with modern scientific software at an early stage of their education, thus, enhancing their motivation while simultaneously improving their skills required in the modern scientific workplace.
- Engineers and computer scientists are expected to acquire new competencies, as advanced mathematical comprehension and the development of soft skills will be supported.

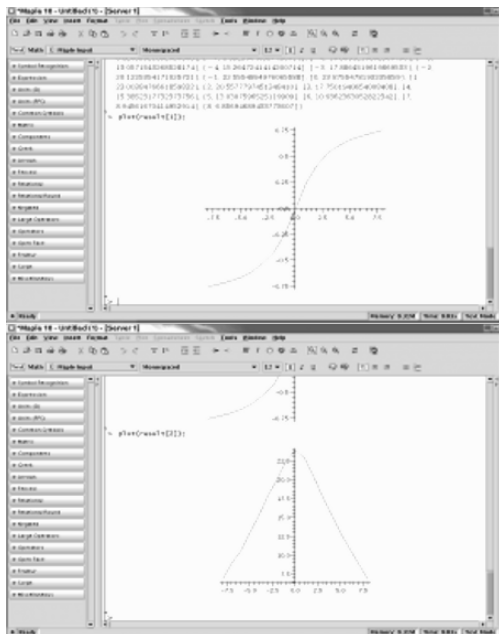


FIGURE 8: Magnetization and Free Energy over external field for $T > T_c$, as collected by Maple.

IV. CONCLUSION AND OUTLOOK

Giving enhanced access to a broad variety of experiments, students can design and execute different types and realizations of experiments – individually as well as in small groups – and investigate the underlying theoretical models. With annually 1,000 students from 10 different fields of engineering, the course “Physics for Engineering Students”, taught in the first and second semester, is one of the largest classes of the TU Berlin. In an extended implementation of this course design, approximately 1,500 students will be reached per academic year.

Integration of state-of-the-art computer algebra systems, numerical software packages, and visualization tools enable students to analyze their experimental data and treat their results further. Thus, students gain the opportunity to get acquainted with modern scientific software at an early stage of their academic education, enhancing their motivation and improving their scientific skills. Through its highly interactive approach, TEUTATES contributes to a modern pedagogy for university teaching, which aims at creative thinking and high level learning, encouraging students to become active learners challenged by complex problems and situations, collaboratively seeking a variety of solutions. Information and Communication Technologies (ICT) are applied to learning purposes and modern pedagogies such as project-based learning, problem oriented learning, principles of non-linear learning, cooperative and cross-cultural learning.

The TEUTATES approach is part of the program of the MuLF center (Center for Multimedia in Education and Research, [1, 12]) of the TU Berlin. It contributes in facilitating and strengthening a modern eLearning-based education as well as cooperative learning activities in experimental and theoretical physics. Through its generic approach TEUTATES is not restricted to the teaching of physics only, but is envisioned as an important prototype for a modern teaching concept in all fields of natural sciences and engineering.

Broad access to virtual laboratories as well as to the remote experiments is an essential part of the eLearning dissemination strategy of the MuLF center. TEUTATES aims at providing all results of the project to non-profit organizations following an “OpenSource, OpenContent, OpenAccess” strategy. Universities, research institutes, schools and other non-profit organisations should have free access to all software components and all scientific results gained in the process of the project including the right for further development. They are free to publish the advancements with non-profit intention only (GPL-like license models).

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Collaborative Virtual Environments for Teaching Physics

Faber Giraldo*, Ángela María Jiménez Rojas†, Pedro Esteban‡ and Helmuth Trefftz§

*Computer Engineering Dept.
Universidad del Quindío, Armenia, Colombia
Email: fdgiraldo@uniquindio.edu.co

†Education Dept.
Universidad del Quindío, Armenia, Colombia
Email: amajir@telesat.com.co

‡Basic Science Dept.
Eafit University, Medellín, Colombia

Email: pesteban@eafit.edu.co

§Computer Engineering Dept.
Eafit University, Medellín, Colombia
Email: htrefftz@eafit.edu.co

Abstract - Eafit University created a Telepresence application for distance education. It supports bi-directional audio and video and a shared virtual environment that allows the instructor and students to manipulate virtual objects in a collaborative manner, thereby reinforcing the learning process. In this paper we report the experience of creating new contents and deploying the tool in a Physics course at Universidad del Quindío. The tool was improved an extended in order to include new functionality and make it easier for development teams to create new content. Teaching for Understanding was used as pedagogical framework for course creation and also as a guide to develop the interviews that were used to capture user's perceptions and to asses the improvements in the learning process. The results showed that the use of the tool had a positive impact on the students' understanding of the topics at hand.

I. INTRODUCTION

Most Virtual Reality applications were, in the beginning, designed for only one user. Through the use of head mounted displays and gloves, the user was immersed in a synthetic world and isolated from the real environment. The availability of the Internet and powerful graphics commodity hardware has made it possible to use shared virtual environments in many applications, such as entertainment (multi-user games), training and education.

In this paper we describe the development of a shared virtual environment application to support synchronous distance education sessions. This tool allows an instructor and a group of students to communicate through bi-directional audio and video, as well as to interact with virtual objects in a shared virtual environment. We call this application a

“Telepresence Application”, since it allows the instructor to be “present” in a distance place: the place where the remote students meet.

This application was first developed in 2004 and used within Eafit University. We intend to make the code available for any institution to use with no cost. The only condition is that contents developed for the course should also be made available for any other institution to use. We hope to have a growing community of institutions creating a growing set of contents that can be deployed in various fields of knowledge.

In this paper, we describe the first use of the application framework outside of Eafit University. The tool was used at Universidad del Quindío to support a distance course on Physics for a degree in Building Construction. A group of undergraduate students created new contents that were deployed in the course. An appropriate pedagogical framework (Teaching for Understanding) was used by the pedagogical team in order to structure the course around the use of the tool and to asses the students' learning process when using the tool.

The rest of this paper is organized as follows: Section II describes similar work and our previous projects on mixed reality in education. Our tool and the contents created for this project are described in section III. Section IV reports the results achieved with the students and, finally, section V describes the conclusions and future work.

II. BACKGROUND AND RELATED WORK

A. Distributed Virtual Reality in Education

Virtual Reality has been used in numerous educational settings. Pantelidis has been studying the impact of this technology in teaching online courses on various subjects, both at K-12 level and college level [1], [2]. They report that

Virtual Reality can be used to support learning in subjects that benefit from interaction with real (or virtual) objects.



Fig. 1. Addition of two vectors in 3D space.

The availability of higher speed networks, low-cost graphics cards and powerful computers, have made it possible to create networked virtual environments that can be used by a large number of users, as explained in by Singhal and Zyda [3]. More recently, Xen et. al built a collaborative virtual reality system called MUVES to create a digitized museum that middle-school students can visit [4]. They report that the system is a powerful vehicle for collaboration and learning.

We have also explored the use of shared virtual environments for university-level education. In [5] we report the building and deployment of the Telepresence tool, used in this paper, to support distance learning. The tool had been used in a Computer Graphics and in an Electromagnetism course. In [6] we describe the use of single- and multi-user augmented reality for tutoring in a Multi-Variate Calculus course. In both cases, the use of the mixed reality tool, hand in hand with the Teaching for Understanding framework, lead to more profound understanding of the concepts by the students.

B. Teaching for Understanding

In the previous projects we have used Mixed Reality applications for teaching Math [7] or Physics, we have used Teaching for Understanding (TFU) as pedagogical framework. The combination of an innovative tool with the appropriate pedagogical approach has fostered students' understanding of the topics in relation with their environments. In this way, concepts become immediately pertinent, since they can be used to solve meaningful problems.

Teaching for Understanding can be used in all phases of the teaching/learning process. It has two main components: dimensions and components. Dimensions serve as guidelines

to design the activities of the course in an integral manner; components allow for the actual deployment of the course design. TFU proposes four dimensions: (i) contents, directly related to the curriculum, (ii) methods, or particular ways to create new knowledge, particular for each field, (iii) praxis is the way how the knowledge is applied and (iv) communication, related to the specific language of the field of knowledge.

The four components are: (i) Goals of understanding: what level of understanding will students achieve at the end of the learning process, (ii) Generative Topics: what motivates students to understand the really main ideas of the course, (iii) Performances of Understanding: what activities do students undertake in order to, increment and, at the same time, demonstrate their understanding? (iv) Continuous Assessment: How to measure students' advances and understanding? [8]

There is a tendency to assign all parts of a curriculum the same relative relevance, and to present all parts in isolation, without any relationship among them. When using TFU, one of the first tasks is to determine the most important topics in the subject, in order to concentrate on them. This means that



Fig. 2. Movement in the presence of friction.

the objective is not to cover all parts of the curriculum, but to give more emphasis to those that articulate better with other parts. Students are asked to dedicate most of the time, energy and resources to those parts. This approach helps students to "...make better use of the developed intelligence, discovering and developing their potential" [9].

This pedagogical framework allows the instructor to define short- medium- and long-term goals; allowing for a prioritization of the subject objectives and their application in the classroom. The way how concepts are presented and the instructor's understanding about them, play a fundamental roll in the development of the curriculum.

III. OUR APPROACH

The development of the Physics I course involve two teams: One team was in charge of the pedagogical approach and the other one was in charge of the technological part. The existing curriculum was used as a starting point. The pedagogical team determined the goals of understanding and the various activities that student should be exposed to in order to reach them. The technology team was responsible for the Java3D implementation of the different contents developed for the course. Each illustration was discussed from both point of view (pedagogical and technological) before their actual deployment in the course.

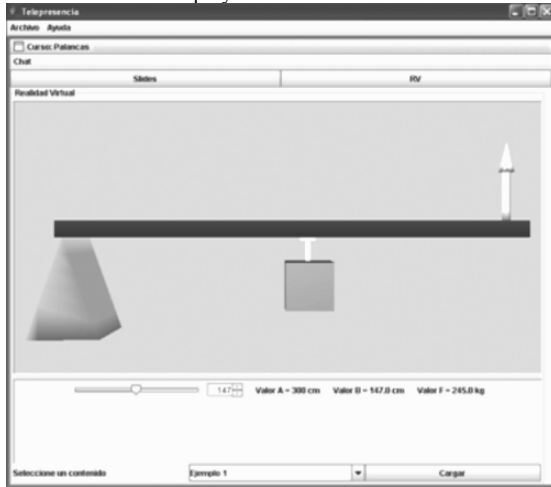


Fig. 3. Levers: users can move the support and change the weight to be lifted.

The Telepresencia tool built at Eafit University was used in a Physics I course taught at the Building Construction Technological program at Universidad del Quindío. This subject covers fundamentals of physics, such as vector operations, Newton laws, simple machines and others.

The program is partly a distance program. This is to say, students meet every 15 days for face-to-face classes, but the rest of the time they study by themselves, following the distance program guidelines. Each meeting takes four hours, and students receive tutoring on the subjects they have prepared previously. Instructors can also assess the learning process via workshops or exams.

In this case, there were 21 students in the class, each of them with diverse backgrounds. Some students had almost no previous experience using computers, while others had a basic experience using them. Students live in several cities and towns of the region, including various states (Quindío, Risaralda, Caldas and Valle). Their age range goes from 18 to 44 years. Some of the students work as waiters, construction assistants, house keepers, taxi drivers, and bank cashiers.

A. Course Contents

Various contents were created using the telepresence course, covering the following topics:

- Deformation due to external forces
- Vector operations in 3D
- Hanging weights
- Movement in the presence of friction
- Column bases
- Simple Machines

Due to space limitations, a brief description is provided for the following contents:



Fig. 4. Pulleys: the user can select the number of moving pulleys and the weight of the object.

1) *Vector operations in 3D*: This content helps students understand basic vector operation in 2D and 3D. The application is particularly useful to demonstrate concepts in 3D, which are difficult to understand when they are drawn on a whiteboard. Vector addition (through various methods) and vector cross product was demonstrated. Figure 1 describes the addition of two unit vectors in 3D space.

2) *Movement in the presence of friction*: This content demonstrates the movement of an object, under a given external force, in the presence of friction. The student enters the weight of a body, the friction coefficient, and then uses the application to provide an external force and direction. After applying different forces, directions and providing various friction coefficients, the student internalizes the phenomenon. Figure 2 shows the body moving after the force is applied.

3) *Simple Machines*: Using this content, users can play with various types of simple machines. In the case of a lever, for instance, students have to compute the force to be applied at the end of a lever, given the position of the support and the weight at the other end. In figure 3, the arrow size at the right end of the lever describes the magnitude of the force that has to be applied in order to lift the weight.

Content was created to demonstrate the functioning of pulleys. Students can select the number of moving pulleys

(between one and three) in order to reduce the effort done by the avatar.

Figure 4 shows the contents when the user has selected two pulleys.



Fig. 5. Students using the telepresence tool.

B. Pedagogical support

The pedagogical team determined that the best way to present the goals of understanding was through the use of questions. These questions should invite students to think and discuss about the importance of physics, motivating students to explore their environment and find answers to the proposed questions. In an initial session, students were explained the methodology and the following questions were asked:

- How can current technological developments help me to understand Physics in a better way? This question aims at the use of the Telepresence tool. In particular, how theory and practice are integrated through the use of the tool.
- How does Physics influence our daily lives? This question intends students to become aware that physics is always present in their daily lives.
- Which things I use on a daily basis are product of Physics? The idea is to lead students to observe their environment carefully, looking for Physics applications.
- Can Physics help to build a better future? The idea is to invite students to think about their future professional career, and find the roll Physics play in their futures.
- How can I use Physics in building technology? This question invites students to transcend the theoretical concepts in Physics and to visualize its application in Building Technology, so they can use it in their professional lives.

Due to the interest that Physics concepts evoke, it was determined that the generative topic should be Physics itself. Newton laws, electrical circuits and pressure in fluids were determined to be, among other concepts, the goals of understanding. The goals students reached as they progressed through the course were written down in a journal, describing the individual and group achievements throughout the course.

C. Technical developments

The Telepresence tool used in this work was built at Eafit University in 2004. It was built entirely in the Java language. Audio and video were handled using Java Media Framework. For the purpose of this project, the following modifications were done:

- A larger number of codecs was used, in order to accommodate lower bandwidth channels. In the presence of very low bandwidth, the video quality is affected in order to maintain the audio contact. In this case, only one frame is sent over the network every 5 seconds.
- The application was organized as a framework, in order to make it easier for the new programmers to develop new contents. Patterns were used extensively in order to lower the unnecessary dependencies among the classes comprising the application.
- Modifications were done to accommodate various hardware settings. If a 3D tracker is available, for instance, the application starts using it. Otherwise, the interaction is achieved through a regular mouse.

IV. RESULTS

In order to analyze the students' understanding during the course, three tests were conducted: (i) a pre-test at the beginning of the course in order to determine previous knowledge. Students were asked to describe daily life situations in which Physics concepts applied. In most cases, students answered "none, everything is already built". This showed that Physics concepts were only important for people designing building structures. (ii) A test at the end of each experience, with questions about the functioning of the experience and the physical concepts that were demonstrated. All students provided a very positive evaluation of the tool and contents. The part they liked the most was the fact that they could repeat the experience with a content over and over, until they grasped the concept. (iii) A test was done at the end of the experience. When asked about applications of Physics in daily life, all students were able to explain how the concepts of the course were applied in their environment, even in their own houses or buildings in the university.

During the course, a high level of motivation and interest toward the use of the tool was showed. The following behaviors were observed:

- Students made teams to work on the contents, and discussed lively until the result was understood by every participant.
- Students showed a high level of concentration, which was not always the case in the sessions developed without the use of the tool.
- Students checked the results by hand, and in one or two cases found mistakes in the program.
- Students reported a high level of satisfaction and motivation with the tool.

Figure 5 shows several users working with the Telepresence tool.

In the interviews conducted during and after the experience, students reported positive opinions. For instance:

- “Concepts are easily understood when using the tool”.
- “2D and 3D graphics helped me to overcome my doubts, and observe a direct application of the formulas”.
- “The use of 3D objects helped me to understand better than the traditional methodologies”.
- “It is good to be able to observe the demonstration from various points of view”.
- “The tool is agile; we can see the results immediately”.
- “This is an innovative tool; it helps me to understand better than traditional methods”.

In their final projects, students had to report on situations, about their daily lives, in which the concepts learned along the course were applied. They had to build prototypes of those situations and explain how the physics principles apply. In these projects most students demonstrated that they had achieved a profound understanding of the concepts.

V. CONCLUSIONS AND FUTURE WORKS

The results of the application of the tool show that students were highly motivated and achieved deeper levels of understanding along the different dimensions of understanding. The use of Teaching for Understanding helped students to understand the concepts, not only to memorize the formulas or the theory. This fact was very clear in the applications of physics concepts they found on real life situations when developing their final projects. This extrapolation showed, also, that they reached more profound levels of understanding.

We intend to implement the following improvements to the application in the near future:

- To make it multi-point. This will allow one instructor to conduct a session with several student locations.
- To replace the video and audio application. We plan to explore other freely available tools to handle audio and video with better compression rates and lower bandwidth consumption.
- To develop an application that allows non-programmers to create simple contents. The tool should allow instructors with no programming abilities to import virtual objects and define simple behaviors and interactions between objects and its users.

VI. ACKNOWLEDGEMENTS

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Intelligent Testing using Fuzzy Logic

Applying Fuzzy Logic to examination of students

Syed Fahad Allam Shah

Department of Computer & Information Systems
NED University of Engineering & Technology
Karachi, Pakistan.
sfahad@neduet.edu.pk

Abstract— This paper is focused on using the Fuzzy Logic to determine the Human Proficiency in a particular knowledge domain using 'Time' to solve the questions and 'Score' (the number of questions answered correctly) as possible metrics. The outcome of the paper would be a Intelligent examination System that would be used to judge the students for the subjects taught at the under graduate level at NED University of Engineering & Technology.

Fuzzy Logic, Intelligent Testing, E-Learning.

I. INTRODUCTION

The automation of examination system has always been a subject of considerable research and debate in the academia. The author has himself been part of a vibrant teaching institution of repute^[1] for undergraduate education in engineering disciplines where the best system to rate the students still continues to be the one-on-one viva approach. Such an approach is flawed in the sense that the students coming in last may face the same questions as asked earlier, the teacher is limited by time to thoroughly examine the students for the proficiency in a particular subject, time keeping is a difficult job – there is always the possibility of time mismatch due to the delay involved in the distribution of written papers or writing the questions on black board. Further such test aren't adaptive, that is, one may prepare few important topics and still get good marks because the questions thrown at him were the same (in content or difficulty) as those he learnt. Lastly, why not have the academia benefit from the rapid automation plaguing every sphere of today's life.

II. A FUZZY LOGIC AND FUZZY SETS PREMIER

Lofti Zadeh [1] was the proponent of the possibility theory, as a measure of vagueness of information. His proposition was that while probability can be used to measure the randomness of information, it cannot be used to effectively represent the measure of meaning of information. The vagueness is represented in quantitative fashion using a set membership function that can take on values between 0 and 1 to depict the degree of belief in the proposition, often called Fuzzy Set Membership function. The name "fuzzy set" comes from the two distinctive properties of Fuzzy set theory where a member belongs to a set with a degree of certainty/belief (a value

[1] NED University of Engineering & Technology

between 0 and 1) as opposed to crisp membership (is a or is not a member) and that the partial membership is allowed, that is the boundaries between the sets are not crisp (absolute) and consequently the same element can be a member of more than one sets albeit with varying (membership) degree (again a value between 0 and 1).

Fuzzy Logic therefore deals with the truth value of the proposition as a function of the (truth/belief) value of its components, each of which can be true to a certain degree. Thus the Fuzzy Logic allows us to work with fuzzy propositions, which contain fuzzy variables and fuzzy values.

A. Fuzzy Set Operations

The rules for performing set operations of union (AND), intersection (OR) and complement (NOT), that are of most interest to us are stated below [2]

- For Union, look at the degree of membership for each set and pick the lower one of the two, that is as shown in (1):

$$T(A \cup B) = \min(T(A), T(B)) \quad (1)$$

- For Intersection, look at the degree of membership for each set and pick the higher one of the two, that is as shown in (2):

$$T(A \cap B) = \max(T(A), T(B)) \quad (2)$$

- For complement, subtract the degree of membership from 1, that is as shown in (3):

$$T(\sim A) = 1 - T(A) \quad (3)$$

III. FUZZY SYSTEM

The approach to the solution of the problem is the same as outlined in [3]. I have specified the Fuzzy set representation of the two measures used to model the proficiency of the candidate, viz. time and level of difficulty of questions. Next I have defined the Fuzzy set representation of the output that represents the level of proficiency. Then, I proceed to define the FAM (Fuzzy Set Associative Matrix), for specifying the rules for combining the membership of the two measures, with rows and columns labeled using the two measures and the entries defining the membership of the output category in Fuzzified form. Lastly, the Fuzzified output is converted to a

crisp value using the COG (center of gravity method). This last step yield the proficiency category of the candidate along with a certain measure of belief. The steps are outlined in the Fig. 1 below::

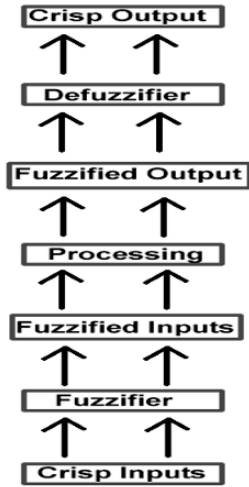


Figure 1. The Fuzzy System

A. Fuzzification of Input Values

The inputs are fuzzified as follows:

III.A.1 Fuzzification of Score Metric

The score metric represent the number of questions answered correctly out of a total of ten questions pertaining to a specific subject area. This measure can be normalized or tailored to suit the number of questions in the examination. I have defined three categories for the universe of discourse starting from 0 to 4 being categorized as *Don't know*, from 2 to 8 being classified as *Somewhat knows* and from 6 to 10 *Completely knows*. This categorization is arbitrary and can be optimized using *Machine Learning* techniques such as *Neural Networks*.

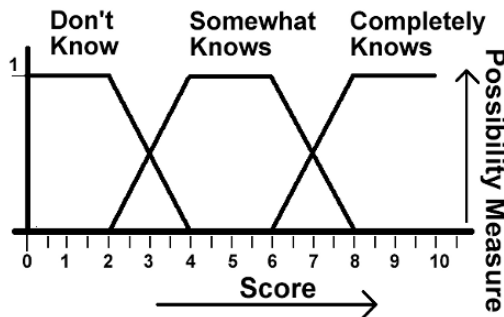


Figure 2. Fuzzy Universe of Discourse for Score Metric

III.A.2 Fuzzification of Time Metric

The second input metric to be used as a measure of the student aptitude is the *Time* taken to answer the question. This notion stems from the fact that the same question may be answered correctly by two students but in different amount of time depending on their facility of proficiency in the subject area. I have used the measure *Fast*, *Medium* and *Slow* but additional levels can also be used. The metric *Fast* is depicted in Fig. 2 from 0 to 8, normalized on a scale of 20 seconds (1 unit=20 seconds), *Medium* from 2 to 18 and *Slow* is demarcated from 12 onwards. Again these demarcations are arbitrary and can be tuned using *Machine Learning* techniques.

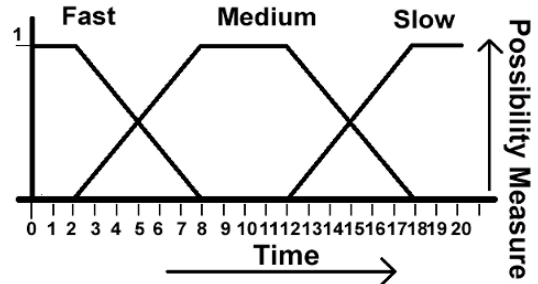


Figure 3. Fuzzy Universe of Discourse for Time Metric

B. Fuzzy Output Values

The Fuzzified output is as shown in the Fig. 3 below. The universe of discourse extends from 40 to 100 on a scale of 100 units with grade *D* demarcated from 40 to 65, *C* from 60 to 80, *B* from 75 to 90 and *A* from 85 onwards. These measures are again arbitrary and can be tuned according to the specific subject area/examination traits.

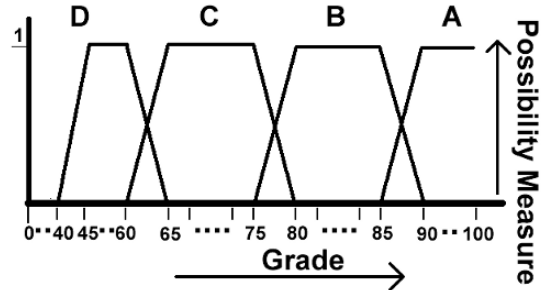


Figure 4. Fuzzy Universe of Discourse for Output proficiency

C. Fuzzy Associative Matrix (FAM)

TABLE I. FUZZY ASSOCIATIVE MATRIX (FAM)

		Time		
		Slow	Medium	Fast
S C O R E	Don't Know	D	D	D
	Somewhat Knows	C	C	B
	Completely Knows	B	A	A

The Fuzzy Associative matrix [3] provides a convenient way to directly combine the input relations to give the *fuzzified* output region. The input values for *time* are across the top of the matrix and the input values for *score* are down the left side. The output region is indicated for each intersection of the input values, for all possible combinations as shown in the Table.1.

D. Defuzzification of Output values

The *fuzzy* output can be defuzzified to obtain a crisp value, using several techniques as described in [3]. I have used CoG (Center of Gravity) technique as described in [4].

IV. EXAMPLE: PREDICTOR IN ACTION

Let us put the *fuzzifier* in action by applying sample values. I arbitrarily chose the values for *Time* metric as 5 and *Scale* metric as 3.4.

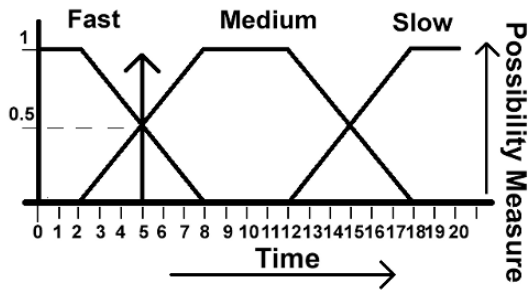


Figure 5. Example value fuzzified for Time Metric

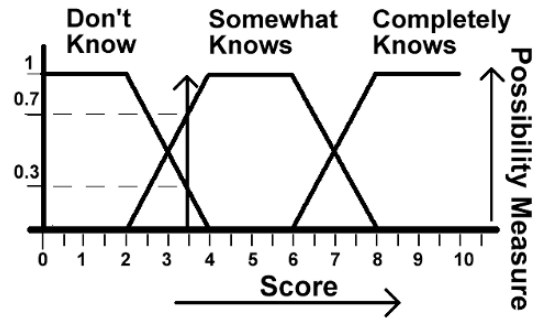


Figure 6. Example value fuzzified for Score Metric

As the Fig.5 shows these measures give the *fuzzified* input values as *Fast* and *Medium* for *Time* metric, each with a measure of belief of 0.5. Similarly for the *Score* metric these values map onto the region of *Don't know* with a measure of belief 0.3 and *Somewhat know* with a measure of belief 0.7 as depicted in the Fig.6.

Next, the output is determined by using the *Fuzzy Associative* matrix for each of the possible input combination. The inputs are combined using the rules for *AND* logic from *Stanford Certainty* algebra and consequently the minimum of the measure of belief is taken as the measure of belief for the (*fuzzified*) output value as follows:

- *Somewhat knows* (0.7) & *Fast* (0.5) => B(0.5)
- *Somewhat knows* (0.7) & *Medium* (0.5) => C(0.5)
- *Don't know* (0.3) & *Fast* (0.5) => D(0.3)
- *Don't know* (0.3) & *Medium* (0.5) => D(0.3)

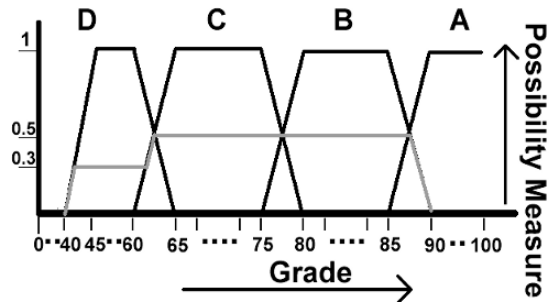


Figure 7. The Fuzzy output from combination of Fuzzy Inputs

These regions are shown on the universe of discourse for the (*fuzzified*) output value as shown in the Fig.7. This gives us the following values from the figure (which can be verified using equation of straight line for the boundary values and from the above (*AND*) rules for other regions):

Y=0 for X=40; Y=0.2 for X=41; Y=0.3 for X=42 to 60; Y=0.2 for X=61; Y=0.4 for X=62; Y=0.5 for X=63 to 87; Y=0.4 for X=88; Y=0.2 for X=89; Y=0 for X=90.

$$\begin{aligned}
 &40(0)+41(0.2)+42(0.3)+43(0.3)+44(0.3)+ \\
 &45(0.3)+46(0.3)+47(0.3)+48(0.3)+49(0.3)+ \\
 &50(0.3)+51(0.3)+52(0.3)+53(0.3)+54(0.3)+ \\
 &55(0.3)+56(0.3)+57(0.3)+58(0.3)+59(0.3)+ \\
 &60(0.3)+61(0.2)+62(0.4)+63(0.5)+64(0.5)+ \\
 &65(0.5)+66(0.5)+67(0.5)+68(0.5)+69(0.5)+ \\
 &70(0.5)+71(0.5)+72(0.5)+73(0.5)+74(0.5)+ \\
 &75(0.5)+76(0.5)+77(0.5)+78(0.5)+79(0.5)+ \\
 &80(0.5)+81(0.5)+82(0.5)+83(0.5)+84(0.5)+ \\
 &85(0.5)+86(0.5)+87(0.5)+88(0.4)+89(0.2)+ \\
 &90(0)
 \end{aligned}$$

$$(0.2) 3 + (0.3) 19 + (0.4) 2 + (0.5) 25$$

Figure 8. Using Center of Gravity (CoG) method to Defuzzify output

Lastly, the output value is defuzzified to obtain crisp value using CoG (Center of Gravity) method as shown in Fig.8:

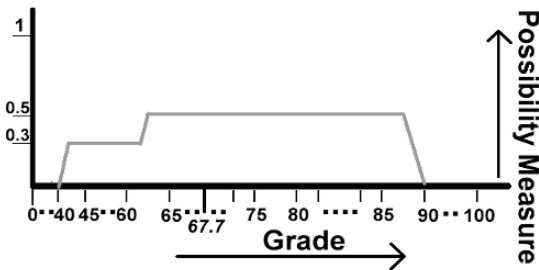


Figure 9. Crisp Output value obtained after defuzzification of Fuzzy output

The answer (crisp value of output) comes out to be 67.7, which maps in the region C, with a measure of belief 0.5 as shown in the Fig. 9.

V. FUTURE ENHANCEMENTS

This simple proof of concept example has been used to give an insight into the application of Artificial Intelligence techniques that can be used for E-Learning software(s)/web application(s). While I have used only *Fuzzy Logic* to intelligently determine the proficiency level of student based on using *Time* and *Score* as metrics, the application can be improved/trained by fine tuning the parameter values for the input metrics and output measures on basis of experimentation and using Machine Learning techniques such as Neural Networks.

A. Authors and Affiliations

1) NED University of Engg. & Tech., Department of Computer & Information. Systems Engineering.

a) Syed Fahad Allam Shah.

2) Sir Syed University of Engg. & Tech., Center for Continuing Engineering Education.

a) Syed Fahad Allam Shah.

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An Experience Providing University Students with Skills to Work with Collaborative Tools

Fuensanta Medina-Domínguez fmedina@inf.uc3m.es

Antonio de Amescua amescua@inf.uc3m.es

Maria-Isabel Sánchez-Segura misanche@inf.uc3m.es

Javier García Guzmán jgarciag@inf.uc3m.es

Computer Science Department, Carlos III Technical University of Madrid

Avda. Universidad, 30, Leganes 28911, Madrid, SPAIN

{fmedina, amescua, misanche, jgarciag}@inf.uc3m.es

Abstract. This paper summarizes the results of an experience in a subject at Carlos III University of Madrid in order to provide Graduate Software Engineering Students with collaborative teamwork skills and the collaborative tools to work with.

I INTRODUCTION

A collaborative web portal is a web site that consists of a set of web pages based on specific criteria from which users can access web services and functionality, and which, depending on the type of collaborative web portal, allows synchronous and/or asynchronous interaction among users who may be geographically dispersed.

Collaborative web portals have their origin in the combination of web portals and collaborative environments fields. A Web Portal is “a point of access to information and applications” [1]. And a CSCW (Computer-Supported Cooperative Work) is defined as “multi-user software applications that enable people to co-ordinate and collaborate on a common task or goal without being in close proximity either spatially or temporally”. [2]

The synergy between CSCW and the Web Portal has emerged recently as a consequence of web technology evolution [2]. Currently, a web portal can be the image of a company, whose clients and employees of a company not only want information, but also a work environment where they can interact with other employees and work collaboratively. The ability to carry out collaborative tasks is one of the current characteristics of web sites, and the web portals equipped with this characteristic are called Collaborative Web Portals.

Collaborative Web Portals are now being used in environments such as medicine [3], industry and different interdisciplinary fields of civil engineering [4]. However, they are ideal for groups of people within the same professional field, e.g. industry and research, where there is a great need for synchronous and/or asynchronous interaction and users are geographically dispersed. In field

of education, collaborative environments have been used in asynchronous learning [5] and in virtual environments [6].

According to the Software Engineering Computing Curricula [7], students should, at some point, engage in effective cooperative working and group learning, which have an increased prominence in the curriculum. Computer engineering students, therefore, need to learn the mechanics and dynamics of effective team participation as part of their undergraduate education. The authors believe that because of the demand for collaborative web portals in business, this technology should be taught in order to equip students with a tool that fosters the above-mentioned skills and prepares them for the labour market. This is why the lecturers and students in the software engineering area at Carlos III University designed a collaborative web portal for lecturers and students to work collaboratively.

This paper is structured as follows: section two describes current collaborative web portal tools in the market and their uses, and the collaborative web portal chosen; section three presents a case study at Carlos III University and section four presents the future lines of work and conclusions.

II BACKGROUND USES AND CURRENT COLLABORATIVE WEB PORTAL TOOLS

Development environments for the creation and implementation of collaborative web portals can be found in the market. These are (the) portal servers which include Sun Java System Portal Server®, Microsoft Sharepoint Portal Server 2003®, WebSphere Portal for MultiPlatforms®, Vignette - Enterprise Content Manage and Portal Solutions®, Builder Suite Portal Server ®.

These portal servers make it possible to develop collaborative web portals with functionalities such as providing better communication among users; connect people, teams, and knowledge across business processes; coordinating work between geographically dispersed teams by linking colleagues, customers, prospects and partners (regardless of/no matter where they are); integrating information from different systems into one solution with

flexible deployment options and management tools; and customizing the web portal.

As mentioned before, the authors of this contribution, who are lecturers at Carlos III University, developed a collaborative web portal so that lecturers and students could work collaboratively. This collaborative web portal was developed with Microsoft Sharepoint Portal Server 2003®.

Microsoft is an international company whose products are used in a great number of organizations, institutions, etc. Microsoft Office® (Access, Excel, Powerpoint, Word) are integrated with servers (one of which is Microsoft Sharepoint Server 2003®), services such as Microsoft Office Online® and operative systems (Microsoft Windows Server®), called Microsoft Office System®. This integration provides an incentive to use Microsoft products because a) they are known and b) used by many. As they are a familiar environment, there is less probability of students rejecting the tool.

Microsoft SharePoint® is made up of Sharepoint Portal Server® and Microsoft Sharepoint Services®. Sharepoint Portal Server® is a Web portals server that lets users integrate different applications, customize the web portal and carry out advanced search. Microsoft Sharepoint Services® allow different functionalities: many add, organize and offer sites to facilitate collaboration on documents, projects, meetings; create and use templates; make the control of versions and publications easy. Sharepoint Portal Server® connects the work site and the different teams of users to provide more efficient organizations.

A collaborative web portal, for example Microsoft Sharepoint®:

- helps to organize changes in the company. Nowadays, many companies are changing from a departmental to a seamless organization where employees from different departments or areas have to work on common objectives, and where the main problem is technology as the traditional technologies (email, folder structure, etc.) are insufficient.
- integrates with other products and tools of the organization. Therefore, the company will have a common point for all employees to access all the tools and products of the organization and work collaboratively.
- provides functionalities such as sharing information, preparing documents.

III USING MICROSOFT SHAREPOINT® AT UNIVERSITY

In this section, we explain how we developed the collaborative web portal to prepare of a subject at Carlos III University, how it was customized and what the collaborative web portal entails.

Microsoft Sharepoint® was implemented at Carlos III University of Madrid in order to:

- Explain to our students how these kinds of systems perform: lecturers analyzed and summarized the behavior of Microsoft Sharepoint® with the unified model language (UML), using two software engineering techniques such as the use cases and sequence diagrams [8], making it easy for students and lecturers to understand Microsoft Sharepoint® facilities. The use cases and sequence diagrams developed can be found at <http://sem.sel.inf.uc3m.es/C8/Investigacion/default.aspx>.

- Use the customized collaborative environment to provide practice with these kinds or systems for both lecturers and students.

Microsoft SharePoint®, was used to manage a subject called “The Application of Information Technologies in an Organization” taught in the Computer Science department at Carlos III University of Madrid. In this subject, the participants were:

- Coordinator; whose function was to design, develop and coordinate the program with all the lecturers involved. He was responsible for tracking the development of the subject, coordinating the preparation of the teaching material, etc.

- Lecturers who teach theory and practice. For a subject to be successful, the two lecturers have to agree on the material.

- Students. They had access to all the information available on each subject and could communicate with the lecturers synchronously and/or asynchronously. They were also able to work collaboratively among themselves, share documents, do practices together, look up information through interest links, plan assignments and follow up their plan, have web discussions and many others functionalities. There were two groups of about sixty students on two campuses: the Superior Polytechnic School in Leganés and Colmenarejo (50 Km far from Leganes Campus), with the same coordinator for both groups, thus ensuring a lot of interaction among the lecturers from both campuses.

As an introduction to collaborative portals, the practice lecturer provided students with the uses cases diagrams showing the main Microsoft SharePoint® functionalities. Students were better able to understand how a collaborative portal works through the use cases tools which helped to improve communication among students and lecturers. Students then used the collaborative portal to perform their assignments in this subject.

The students worked with two collaborative web portals; one to communicate with the lecturers of the subject and with other students, and the other that they developed based on the business process that the lecturers proposed. The two collaborative web portals are explained below.

1.-The collaborative web portal has a principal page called SEL-UC3M (Software Engineering Laboratory-Carlos III University of Madrid). This is a sub-division of the software engineering area in the computer science department. This web page has links to three areas (Fig. 1):



Fig. 1. Home Page of Collaborative Web Portal

- Teaching: this area has links to different software engineering subjects.
 - Members: this is the web page of the lecturers and professor of software engineering.
 - Research: this area has links to research lines of the software engineering lecturers, published works (conferences and journals, research projects, etc.)
- “Teaching” provides a collaborative web portal for students and lecturers of these subjects. This link shows the subjects and the lecturers of each. (Fig. 2).

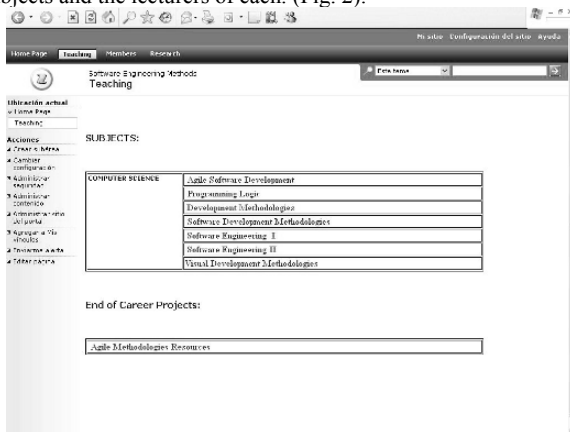


Fig. 2. Web Page of subjects taught by software engineering lecturers.

In this area, the students can access all the software engineering subjects by clicking on the appropriate link.

The design of the collaborative web pages is the same similar for all the subjects to make it user friendly.

When a student chooses a specific subject, the student has links to:

- Program: this area contains the breakdown of the subject.

- Documentation: contains the notes and slides used in class by lecturers, and publications related to the subjects.
- References: provides the bibliography used in this subject.
- Lecturers: contains the important data of the lecturers who teach the subject, for example, where a student can locate a lecturer, the time available for consultation, etc.
- Timetable: contains the timetable and the room number for this subject.
- Norms: provides all criteria: practice grades, exam grades (theory and practice), etc.
- Planning: this area has a table where the students can track the progress of the subject. They can know what the lecturer is going to teach on any given day.
- Practices: this area contains several sections:
 - Download Practices: the lecturers put the practices that the students have to hand by a specific date.
 - Forums: the student can write messages to the lecturer or students. These messages have to be closely related to the practices.
 - Examples: the lecturers indicate links to previous practices.
 - Software: the lecturers add links to the software that the students need for the subject.
 - Work Areas: the practices are made up of a group of students (in general, a group is made of five students). The lecturers enable a work area for a group of practice so that each student can communicate with his/her partner. This site provides them with a place where they can:
 - do the practice
 - leave the documentation they have created
 - add the link to the collaborative web portal they created
 - have virtual meetings
 - make decisions on the practices.
 - send a message to the lecturer to clarify doubts on the practices or theory
 - Etc.

- Grades: when the students are graded, the lecturers leave the marks in this area.

The area called “Members” provides the web pages of the lecturers, where you can see the curriculum of these lecturers.

Research provides several links to research lines of the lecturers, e.g. their published works, conferences, journals, research projects, theses, collaborative work on joint research, etc. (Fig. 3)

on the need of each portal. In this case, for example in the writing area, the portal designer created the following roles:

- Chief editor: this person had the full control of this area.
- Editor: this person could read and insert information but could only update the information of some sites of this portal.
- Journalists: these people can read and insert in some part of this area.



Fig. 5. Home page of the Collaborative Web Portal for the journalist.

In the collaborative portal, journalists collaborate in two ways:

1. - The collaboration among the people that work in the same area.
2. - The collaboration in different areas. This occurs when several journalists of different areas have to collaborate on the same activity. As the journalists cannot access each other's areas, the portal designer will create a collaborative site with access from the different areas of each person involved in the activity.

Both are possible through the collaborative functionalities that Microsoft Sharepoint® offers. These include:

- Sharing information, documents, images...
- Giving opinion on a topic through panel discussion.
- Planning timetable with the different activities and the roles to accomplish them.
- Tracking the activities and tasks
- Meeting areas with the assistant, relevant document, etc.
- Looking for knowledge, people.
- Customizing the personal site.

- Adding alerts (the system advise the journalist when some operations that he/she had programmed is completed, for example, if someone added a task for a specified worker, then the alert would send the worker an email advising him/her to check his/her task list)

- Integrating with other applications of the newspaper, for example, database of human resources.

- Integrating with Microsoft Office® (Word, Excel, Access, Outlook,...). With Microsoft Word®: the people can work on the same document. The system synchronizes the changes made by the different journalists which are a transparent operation for the journalists. Through Word, journalist can work in a collaborative work area of Microsoft Sharepoint® with no added cost, have web discussions on the document and add comments for other journalists, etc. With Microsoft Outlook® it is possible to manage meetings, make appointments, send e-mails, etc.

The workflow of the journalists is implicit in the collaborative web portal which was designed and programmed by the portal designer, in this case, the students. So, the students analyzed the system and obtained the requirements. Next, they designed the previous collaborative web portal, simulated the daily tasks of a newspaper and presented the portal in class.

IV CONCLUSIONS AND FUTURE TRENDS

The case study has proved to be positive. Through the collaborative web portal the lecturers managed and designed different subjects and they worked collaboratively with each other and with the students.

Skills in the management of collaborative web portal are in great demand by organizations. Therefore, using this technology at university prepares students for the real demands in the work place.

The communication among students and lecturers was very fluent. The coordination of activities among lecturers as well as the design of the subject contents among some lecturers and tracking the subject schedule improved.

This experience can be repeated for different subjects in other fields due to the positive results obtained.

The main problems with Microsoft Sharepoint®, were the dependence on the expert of this tool and communicating with him. These were solved with the description of the main functionalities of Microsoft Sharepoint® use cases. These techniques made communication between clients, in our case the university lecturers and the experts in the tool Microsoft Sharepoint®, easier.

Due to an improvement in communication among students and lecturers, we believe that the use of collaborative web portal technology in software projects development can improve the communication among stakeholders. As a result, we plan to implement specific web parts, coded in visual .NET to support specific software processes in a software project

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Designing an e-Learning System for Language Learning: A Case Study

Gerhard B van Huyssteen

Centre for Text Technology (CTeXt), North-West University, Hoffman Street, Potchefstroom, 2531, South Africa
Email: ntlgbvh@puk.ac.za

Abstract – Within the South African context, e-learning provides various opportunities to contribute towards a multilingual society. This paper describes a new project, ICALLESAL (Intelligent Computer-Assisted Language Learning for Eleven South African Languages), where an e-learning system is being developed for the acquisition of the official South African languages. The paper commences by defining computer-assisted language learning (CALL) and intelligent computer-assisted language learning (ICALL) within the context of e-learning. The benefits of CALL within the South African context are discussed, with specific focus on how it could promote a culture of multilingualism, and also help towards bridging the Digital Divide in South Africa. In the subsequent section, the ICALLESAL system is discussed in more detail by presenting various technologies, content objects, and features of the system.

I. INTRODUCTION

In 1997, Lut Baten and Bert De Coutere (Catholic University of Leuven, Belgium), together with Daan Wybenga and Gert Jooste (Vista University, South Africa) conceived of e-learning courseware for foreign language acquisition, called *Multitaal*. In subsequent years, and in collaboration with colleagues from various other universities, this authoring language was used to develop interactive, multimedia e-learning courseware for various languages and various target groups, such as *InStap!Nederlands* (1999; for Dutch), *InStap!E4B* (2001; English for business purposes), *InStap!Afrikaans* (2002; for intermediate and advanced levels of Afrikaans), *Tsenang!* (2004; for Setswana), and *Ngenani!* (2004; for isiZulu).

Since the release of the latter two programs, the Centre for Text Technology (CTeXt) of the North-West University in South Africa has taken over the South African part of the project, and acquired all Intellectual Property Rights. Since then, CTeXt has continued with commercialization initiatives, the release of updates, and the development of similar programs for isiXhosa (called *Sondelani!*), and Afrikaans as a foreign language (called *Dagsê!*). (Henceforth, I will refer collectively to all of these software packages as the "*Multitaal* programs"; when referring collectively to only *Tsenang!*, *Ngenani!*, *Sondelani!*, and *Dagsê!*, I will use "*Multitaal SA* programs".)

However, despite the successes of the *Multitaal SA* programs in the South African market, these programs have some significant weaknesses and limitations, such as no connec-

tivity (limiting true interaction between learners, and also limiting network solutions for corporate clients), weak multimedia content, a rather unintuitive end-user interface, and outdated back-end technologies (e.g. a 16-bit Paradox database and interfaces developed in Delphi 3). A complete overhaul of these programs is thus inevitable, either directly through reengineering measures (e.g. transportation of existing databases to new database technologies), new design (e.g. new multimedia objects, and new content objects for the acquisition of language for specific purposes), or otherwise through the introduction of new components (e.g. Human Language Technology (HLT) components).

With a view to address these shortcomings, CTeXt initiated a project late in 2005, called *ICALLESAL: Intelligent Computer-Assisted Language Learning for Eleven South African Languages*. At the first conceptualization think-tank, held in November 2005, which was attended by role-players and stakeholders from across South Africa, the broad aim of this project was presented as follow:

To develop an online intelligent computer-assisted language learning system for eleven South African languages, based on the pedagogical concept and linguistic content of the Multitaal SA programs, but using new, cutting-edge technologies, with a view to the stimulation of Natural Language Processing research, the development of a Human Language Technology industry, and the promotion of multilingualism in South Africa.

This is the first project of its kind (in both focus and scope) in South Africa, and will draw in all the major role-players in the fields of HLT and Natural Language Processing (NLP) in South Africa (i.e. North-West University, Universities of Pretoria and Stellenbosch, and Meraka Institute). Additionally, partnerships with relevant Black Economic Empowerment enterprises are being established, while the involvement of international collaborators (in addition to the Catholic University of Leuven) is also being investigated. Currently, the project is in the Design phase, with a view to sign-off the final project charter by the end of January 2007. A first thin-slice prototype has also been developed, while a first prototype is being developed currently for deployment in a pilot study in various branches and contact centers of a major South African banking group.

This paper presents the design of the ICALLESAL system in more detail. In the next section, the use of e-learning solutions for language learning is defined and discussed, with a specific focus on how e-learning strategies could promote a culture of multilingualism in contexts similar to the South

African context. Section III presents the ICALLESAL system in more detail, focusing on defining features of the system. This paper concludes with a summary of the advantages of ICALLESAL over other e-learning solutions available for South African languages.

II. LANGUAGE LEARNING THROUGH E-LEARNING

A. Defining CALL and ICALL

E-learning is generally understood to be learning facilitated and supported through the use of information and communication technologies (such as CD-ROMs, websites, discussion forums, web logs, wiki engines, podcasts, email, video conferencing software, collaborative software, interactive television, audio and videotapes, etc.), made available either locally or via intranet, Internet, or satellite, and delivered using personal computers, digital television, etc. When mobile devices such as Personal Digital Assistants (PDAs) and mobile phones are used for delivery, e-learning is often called mobile learning (m-learning). E-learning can cover a spectrum of activities from supported learning, to blended learning (the combination of traditional and e-learning practices), to learning that is entirely online. Whatever the technology, however, learning is the vital element [1].

When e-learning strategies are employed for language learning and teaching (especially with regard to foreign language acquisition), it is most commonly referred to as computer-assisted language learning (CALL; also known as computer-/technology-enhanced language instruction/learning) (cf. [2]). Although a fairly recent interdisciplinary subject (i.e. over the last forty years – [3], [4]), CALL is considered by and large as "one of the success stories of the end of the twentieth century" [5], with various academic journals, conferences and associations dedicated to this field of enquiry, and an almost endless supply of products, websites and material available for most commercial languages of the world. Nonetheless, CALL can still be considered in its youth, with much research and development work still to be effected.

One of the areas of CALL still in its infancy is so called intelligent computer-assisted language learning (ICALL). In its broadest sense, ICALL can be defined as Artificial Intelligence-based CALL, where tools, techniques and strategies from the field of Artificial Intelligence (AI) are applied to language teaching. This includes, most notably, the development of intelligent tutoring systems and interactive learning environments [6], [7].

More narrowly defined, and as the term is used specifically within the ICALLESAL project, ICALL is simply defined as "CALL incorporating Language Technology (LT) techniques" [8], [9]. These include, for instance, morphological analyzers used for intelligent dictionary look-up procedures of inflected and derivational forms, syntactic parsers in grammar checkers for evaluating freestyle input, spelling checkers for giving feedback on spelling matters, speech recognizers for evaluating pronunciation and for automatic, individualized assessments, virtual chatbots for increased interac-

tivity, etc. Reference [10] summarizes the current state of ICALL when it states that "research in HLT in CALL is vibrant" and that "HLT has an important contribution to make in the further development of CALL." Since both HLT and CALL are relatively immature disciplines many ICALL projects "have not even reached the stage of the implementation of a fully functional prototype yet. However, successful CALL projects which utilize the advantages of HLT (and avoid some of the pitfalls) are testimony to the fact that these new language technologies have a lot to offer for the development of CALL software that learners can use more easily, more effectively and more naturally" [10].

B. Potential of CALL in South Africa

The advantages and disadvantages of traditional methods of language teaching versus CALL are often discussed in the literature (e.g. [4], [5], [11]). Table 1 presents a summary of some of the main points where these two approaches differ, with a stronger focus on the positive aspects of CALL. (For some negative myths about CALL courseware, see [12].)

One facet of the comparison that is still yet unresolved (also in the available literature) is the cost implications of these two approaches. With regard to initial development cost and cost of maintenance (e.g. updates), traditional approaches are believed to be cheaper than CALL systems (i.e. dedicated CALL courseware is very expensive in terms of programming costs, creation of original multimedia content and user-interfaces, systems integration, etc.). However, in terms of delivery CALL courseware is cheaper than traditional methods – not only in terms of the physical delivery per capita (e.g. on CD-ROM or via the WWW to literally millions of learners versus human teachers with restricted numbers of learners), but also in terms of indirect costs (for example, a company will have to pay for employees' traveling costs, accommodation and daily sustenance if the company requires employees to acquire multiple languages).

Another facet that is still yet unresolved is whether the one approach will produce the same results in less time than the other approach. It is generally assumed in the literature that language skills for basic communicative purposes (e.g. greeting, buying something in a store, ordering something in a restaurant, etc.) could be acquired in 40 – 60 hours of learning time; to acquire language skills for more advanced communicative situations (such as engaging in conversations about politics, sports, etc.), a learner would need between 130 – 160 hours of learning time. It is also widely assumed that the quickest way to learn a language is to be assimilated and isolated in the target language community; however, in a multilingual society such as South Africa, this is almost impossible, since a learner can almost never be isolated from other language communities (left alone to free an employee to spend 160 hours away from work to acquire a new language). Learners (and their employers) are therefore faced with the challenge to find solutions to effectively decrease the learning time required to acquire a new language.

TABLE 1
COMPARISON OF TRADITIONAL LANGUAGE TEACHING AND CALL APPROACHES

Traditional	CALL
Delivery: One-to-Many (one human teacher, many learners).	Delivery: One-to-One (one virtual teacher, one learner).
Mostly, only one language of instruction is possible in a classroom.	Many languages of instruction could be implemented in the same program.
The teacher has to consider the collective aims and progress of the group as a whole, with little room for the needs of individuals (e.g. to learn a language for specific purposes). Repetitive actions are strenuous and time-consuming.	The language learning experience could be individualized, taking the aims and progress of the individual into consideration. Material can be repeated as often as the learner wants to.
Learners are subjected to the teacher's methodologies, language usage (e.g. pronunciation) and norms for assessment.	Programs could provide for different learning styles, different varieties of the language, as well as more objective assessment.
Learners are often confined to learner centers and the availability of courses in their geographical area. Moreover, learners are bounded by course schedules and time-tables.	No restrictions apply to the availability of courses, especially with online and/or mobile learning (i.e. overcome limits of physical mobility). Learners can access material whenever and wherever they want to.
Performance of learners is often inhibited by performance anxiety (e.g. to speak in front of other learners).	Learning takes place in a "safe" environment, where the learner can practice skills more freely.

In South Africa, with eleven official languages, various other current tendencies and factors make CALL an attractive opportunity to explore at this point in time. For example, sales of the current *Multitaal SA* products clearly indicate that there is a definite market need (demand) for CALL products in South Africa, most probably because of a changing multicultural, multilingual work and business environment. It seems as if there is a growing awareness of multilingualism amongst people (cf. [12]), despite the fact that a recent survey by Plus 94 Research indicated that 64% of South Africans favor English as the country's "main" official language and preferred language for business communication [14]. However, incongruence exists between language preferences and language proficiencies, especially with regard to second languages. For example, various research projects indicate that between 19% and 31% of the total population has no understanding of English (compared to, for example, Setswana: 63%; isiNdebele: 67%; Tshivenda: 83%), while between 22% and 47% have a thorough comprehension of English (compared to, for example isiZulu: 49%) [15]. From this it is clear that levels of second-language proficiency in South Africa, even in English, are challenging, and should be kept in mind when making business decisions. For instance, no large public-sector service enterprise can actually afford to have an "English Only" language policy, since they won't be able to reach almost a 1/3 of the population.

This general awareness of multilingualism is also reflected in the business world's reaction to market needs. For example, major South African banking groups like ABSA and

NEDCOR have introduced multilingual service channels, with ABSA currently taking the lead by offering eight languages on Automatic Teller Machines, and four languages for telephone banking. Moreover, corporate businesses are also under constant pressure to deliver services in multiple languages – for instance, section 3.4 of the *Code of Banking Practice* [16] explicitly states that services and products should be provided "...where appropriate in any of the other official languages."

In addition to businesses, government departments are also obliged to make information and services available in multiple languages. Not only is it required by the *Constitution of the Republic of South Africa* (1996; chapter 1(6)), but also by the *Draft South Africa Languages Bill* (2003) and the *National Language Policy Framework* (2002), amongst others.

In order to sustain and/or expand multilingual services and products, civil servants and employees will have to acquire additional languages, improve their current language skills, and/or expand their language skills for specific purposes (i.e. to acquire vocabulary and linguistic constructions for specific situations, such as working as a teller in a bank, or as a civil servant dealing with passports). Given the advantages of CALL listed in Table 1 above, dedicated online CALL courseware could afford opportunities to empower people (specifically adults) to acquire these skills, thereby contributing to a true culture of multilingualism in South Africa. Moreover, CALL programs hold the promise to contribute towards bridging the Digital Divide (i.e. the divide between the privileged and the marginalized in terms of access to technology, specifically computers and related applications), by helping towards e-inclusion, social integration and upward mobility.

Given these opportunities that e-learning and CALL afford, the ICALLESAL project aims to develop such a dedicated online ICALL system for all eleven official South African languages.

III. SOLUTION: ICALLESAL

The ICALLESAL system is a dedicated, distributed system, where dedicated means that it is developed for specific purposes, and not integrated in another system. In terms of Reference [4]'s distinction, it is therefore a tutor (courseware), rather than a tool. Distributed implies that it is a connected, online system, running either via a web server, a local server, or else via both. This affords opportunities for learners to learn both at work and at home (provided that they have internet access at home). Moreover, such a connected system offers various possibilities for user interaction, advanced learner management, and customisation (see discussion below). Due to challenges with regard to internet availability and channel capacity (bandwidth) in South Africa, connectivity is currently limited to certain functionalities (e.g. updating of software, submission of results, communication with trainers and other learners, and connection to the ICALLESAL website). The end-user program is hence also client-based, rather than browser-based.

As a design model, we have chosen Colpaert's Research-Based, Research-Oriented (RBRO) design model [12]. This model "is based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), in which each stage delivers output which serves as input for the subsequent stage" [12]. The engineering loop implies that this is an iterative process, where the design can be adjusted after each implementation and evaluation, if deemed necessary. In terms of this model, the ICALLESAL project has already been through the first Analysis stage, where information was gathered "about all possibly relevant epistemological, empirical, actorial, contextual, technological, feasibility-related, and perceptive aspects, facts, findings, principles, and considerations" [12]. Currently we are in the first Design phase, where the concept is elaborated (conceptualization), the architecture is described in terms of components and their interactions (specification), and discrete topics are being tested using available technologies (prototyping) [12]. As mentioned in Section I, a first prototype is currently being developed for implementation in a pilot study, and is scheduled for completion by the end of January 2007.

Next, some of the key defining features and unique functionalities of the ICALLESAL system are discussed in more detail.

A. Eleven Languages

More than 40 languages are spoken in South Africa, of which only 11 are recognised by the Constitution as official languages. Of these 11 languages, isiZulu is the largest home language (first language), followed by isiXhosa and Afrikaans.

Within the context of language learning, a distinction is generally made between the *Target Language* (i.e. the "Learning Object", the language you want to acquire); the *Source Language* (i.e. the native tongue of the learner); and the *Medium of Instruction* (i.e. the language used to teach and explain). The ideal, of course, would be to develop a system with *eleven* target languages, through medium of *eleven* languages. This is also the eventual, long-term goal of this project. However, for practical and financial reasons, some delimitations had to be decided on. Although all eleven languages will be developed as Target Languages (in the following priority sequence: isiZulu; Afrikaans; Sesotho; English (Business English); isiXhosa; Sesotho sa Leboa; Xitsonga; Tshivenda; Setswana; siSwati; and isiNdebele), the Medium of Instruction will be restricted to one language only (English), with the possibility to extend to Afrikaans and other languages in future. Given the general architecture and design of the system, it would also be possible to expand the language offering to other languages (of Africa), such as French, German, Portuguese, Kiswahili, and/or Arabic.

B. Advanced Learner Management

In any e-learning system, learner management is of utmost importance. Some of the advanced features in the ICALLESAL system include (amongst others) *progress reports* for learners and trainers, with statistical analysis of progress; a "*Virtual Trainer*" (i.e. automatic agent) that monitors learners'

frequency of access to the system, probes learners' via e-mail or SMS to access the system (e.g. "You haven't logged on to the system for 5 days! Maybe it's time to learn again!"), and sends early warning signals to human trainers/managers; and *integration of e-portfolios* in other HR management systems, such as SAP. A user therefore builds up a "linguistic profile", which could be added to his/her profile on the HR management system.

C. Enhanced Communication/Interactivity

Researchers across the board agree that peer-communication and interaction with other language users/learners are essential for language learning. ICALLESAL deploys various communication and interactivity tools such as *email* (with peers, or with trainer for asking questions); *chat-bots* (i.e. virtual, artificial intelligent agents, simulating human communication); *wiki's* (where a learning community creates its own, shared works of reference, such as terminology lists, lists of frequently asked questions, etc.); *discussion forums* (where learners help each other to solve problems, or where trainers could comment on unresolved issues); and *playful competitiveness* (with high-scores for games and exercises, best performer of the month, etc.).

Interactivity is further enhanced through enticing exercises in the form of small *games* (downloadable to portable devices). Worldwide research confirms the suitability of using games in e-learning, and specifically computer-assisted language learning. By creating a *playful, escapist environment*, users "learn as they play": instead of playing *Solitaire* or *Hearts* during a break, s/he could rather play a language game. The didactical "Learn, Practise, Prove Principle" is integrated in such games, while users can also access websites of accredited institutions to acquire more formal recognition for their skills (e.g. certificates of proficiency, etc.).

D. Customization Possibilities

One of the key distinguishing characteristics of ICALLESAL, is the advanced possibilities to select and manage content. So-called "shopping cart" functionalities are implemented, where learners and/or trainers can select the content relevant and functional to their needs and levels of proficiency. Such customisation is based on *automatic assessment* (i.e. the learner's proficiency is evaluated, before s/he can access certain modules); and/or *managed by a human trainer* (e.g. the trainer/manager decides which modules should be completed by which learners); and/or *managed by learner* (e.g. the learner can "shop" those modules that s/he is interested in). This ensures optimal learning, since learners engage with learning material that is relevant to their day-to-day operations.

To illustrate the necessity of customisation specifically with regard to vocabulary, consider the data in Table 2, which presents a word-frequency comparison between two equally sized (n=4,182) sets of texts (i.e. a random selection from the *British National Corpus* (<http://www.natcorp.ox.ac.uk>), and a training manual from a South African bank). The words in italics are words that do not appear in the 20 most frequent words of the comparative corpus. What is clear from this

TABLE 2
COMPARISON OF WORD FREQUENCY IN BRITISH NATIONAL CORPUS AND BANKING TRAINING MANUAL (N=4,182)

Rank	British National Corpus	Frequency	Banking Training Manual	Frequency
1	the	304	the	335
2	of	156	card	150
3	to	129	to	111
4	and	93	and	89
5	in	91	client	81
6	a	88	of	81
7	for	50	be	65
8	be	49	number	64
9	by	46	is	63
10	that	43	on	61
11	is	40	this	55
12	it	40	that	54
13	are	33	form	45
14	as	26	enter	44
15	was	25	a	42
16	Lord	24	ATM	40
17	said	24	in	38
18	he	24	if	36
19	from	23	or	35
20	on	23	will	35

small-scale investigation is that 50% or more of the 20 most frequent words in specialised texts do not appear in the 20 most frequent words of general corpora. Therefore, in order to optimise the learner experience and increase the learner's functional proficiency in the target language, a tailor-made solution would be preferable. Instead of learning about "cats" and "dogs", or conveying condolences to an uncle or aunt, the learner would rather engage with relevant material to his/her immediate working environment.

Other customization options include real-world simulations of relevant functions and communicative situations (e.g. answering a telephone, dealing with a difficult client, etc.), incorporation of a corporate client's brand identity (e.g. by including insignia in the graphical user-interface), and system integration (e.g. integrating e-portfolios with a corporate client's human resource management system).

E. Didactical Approach

Given the fact that CText already possesses the Intellectual Property Rights of the *Multitaal SA* programs, the ICALLESAL project was conceptualized as a reengineering project from its very inception. This provides the opportunity not only to build on current strengths and improve on weaknesses, but also to ensure increased speed-to-market.

One of the main strengths of the *Multitaal* programs is the hybrid approach to language acquisition taken in the pedagogical design. Not only does this approach afford the best of both worlds in terms of pedagogical tools and methods, but it also accommodates different learning styles and learning

strategies across learners [17]. On the one hand, an interactionist, functional approach is followed, combined with a more classical ("grammatical") approach. Reference [18] describes the implementation of this approach as follows: "The grammatical sections and the... communicative functions contain references to lexical items and the dictionary includes grammatical and communicative information. Integration also means that examples in the grammar and sentences in the exercises are taken from the communicative sources the user is acquainted with." This hybrid approach therefore presents the learner not only with authentic contexts and typical communicative situations, but also with enriched input ([19]) in the form of works of reference. These works of reference include dictionaries, grammar guides, function guides, and pronunciation guides.

The *dictionaries*, which are downloadable on mobile devices, include words, phrases and collocations relevant to specific domains (depending on the customisation options the user has chosen); i.e. general words like "cat" and "dog" will not be included in a specialised banking environment, while specialised words like "account", "client" or "card" will be amongst the first words a learner will encounter.

The *grammar guides* (also downloadable on mobile devices) contain some basic constructions (such as questions, statements, or commands), while specialised constructions relevant to the working environment (such as on-screen commands, or three word commands) are included in specialized modules (based on extensive corpus research).

The *function guides* provide information on basic functions such as counting, names of the days and months, etc. More specialised functions (such as forms of address, filling out of forms, giving a telephone number, etc.) form part of advanced modules.

In the *pronunciation guides* (also possibly downloadable on mobile devices) speech synthesis (i.e. artificial speech) is used to provide a user with audible examples of words or sentences s/he types in. Further functionalities include the incorporation of an automatic speech tutor, which analyses the speech of the learner, and gives him/her instant and detailed feedback. The full potential of pronunciation guides will be explored in research conducted by Meraka Institute and University of Stellenbosch, in a subproject funded by the South African governmental Department of Science and Technology.

Moreover, elaborate sections on cultural knowledge perpetuate culturally responsive teaching, which is essential for the learning experience and the sense of belonging in a cultural space [20]. In addition, we also believe that it is important for learners to learn contextualised slang and colloquial usage (e.g. the Afrikaans loan word *lekker* 'nice' in English, or the English loan word "nice" in Afrikaans), to ensure a more natural assimilation into the target language community.

Since this linguistic content is chosen, organized and authored by experienced foreign language teachers, and validated by native speakers, the learner is presented with efficacious information on the essentials of the language, which will enable him/her to maximize his/her learning experience.

TABLE 3

COMPARISON OF ICALLESAL WITH OTHER CALL SOLUTIONS

ICALLESAL	Other CALL Solutions
<i>Integrated, connected learner management</i> (e.g. learner progress is stored on a central server, integrated with HR management system).	Learner management is often "paper-based" and done by a human trainer.
<i>Automatic motivation</i> (probing) and progress management of learners.	Trainer has almost no control over the time learners spend on self-study.
Content and "Look&Feel" is <i>tailor-made for corporate client</i> , conforming to their needs, lingo and jargon, and brand personality.	Content and "Look&Feel" is aimed at a general target market (often tourists).
Easily <i>customisable</i> for individual needs and levels of proficiency of a learner.	Very little customisation possible.
Simulation of <i>real-world communication situations</i> , relevant to corporate client's employees.	General communicative situations (e.g. "At the restaurant", "Families", etc.).
Downloadable components and remote access via internet create even <i>more flexibility</i> for users to access learning and reference material.	Learners are bound to desktop computer where programme is installed.
<i>Interaction</i> between peers and trainers are integrated in the system, freeing users from the limits of time and space (i.e. virtual workgroups).	Learners must find own solutions to ensure interaction with other learners, while contact with trainers is often restricted to training sessions and personal appointments.
<i>Hybrid approach</i> to pedagogical design allows for various learning styles and strategies.	Mostly either purely "classical", or purely "communicative" – learners have to adapt their learning styles to the software.
<i>All languages</i> integrated in one system (expandable to other languages). Learners therefore only have to acquaint themselves with one learning environment, while the immediate availability of other languages might also stimulate learning of multiple languages.	Only <i>one language</i> per package. Learners have to buy/register for a completely new package to acquire another language.

E. Mobile Components

As mentioned above, various components will be downloadable to mobile devices, which will cross the line from pure e-learning to m-learning. This will not only afford learners the opportunity to learn "on-the-go" (e.g. while waiting for a bus or train), but also provide them with the necessary tools wherever they might be (e.g. to quickly look up a word when you are at home, etc.). This aspect of ICALLESAL will also prove to be innovative in the field of language learning.

IV. CONCLUSION

Based on the above, Table 3 presents in summary and in conclusion the advantages of ICALLESAL over other CALL solutions that are available for South African languages. Despite these advantages of ICALLESAL, learning will however not take place "automatically": a cultural change (and the management of such change) will need to be implemented in any corporate environment. This could, for example, include the introduction of incentives for employees with multilingual

profiles, or for people who have successfully completed a language course. Also, a culture of e-learning has to be introduced, in order to facilitate a smooth transition from more traditional approaches to an e-learning approach.

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E-Learning Tool & Remote Experiment on Simulation of the Control Systems used in Electrical Domain

Gheorghe Scutaru, Paul Borza, Vasile Comnac
"Transilvania" University Brasov,
Brasov, Romania
Ingmar Tollet, Seppo Lahti
EVTEK University of Applied Sciences,
Espoo, Finland

Abstract:The paper proposes an innovative approach of the teaching method using a virtual & remote laboratory. The e-learning product consists of two parts: the theoretical part and the remote experiment. The e-learning tool presented in this paper has been accomplished in the Leonardo da Vinci pilot project Virtual-Electro-Lab.

I. INTRODUCTION

The e-learning tool presented in this paper has been accomplished in the Leonardo da Vinci pilot project *Virtual-Electro-Lab* [1], [2]. The accomplished software-tool set is destined to the teachers that perform didactical activities in electrical domain and it meets a fundamental didactical need: the lack of an intuitive support from practical life that guides the deep understanding. The software-tool set is divided into three packages: *Package 1*, in electrical domain: "Properties and characteristics of the materials used in electrical domain"; "Simulation and computing of electrical circuits"; "The electrical transformer and the induction machine". *Package 2*, in electronic domain: "Measurements of electronic devices and circuits"; "Measurement & automated test systems"; "Home appliance systems (DOMOTICS) and peripheral components". *Package 3*, in automation domain: "Simulation of the electric drives"; "Designing and simulating of the control systems used in electrical processes" , presented in this paper; "Web-oriented applications on databases used in electrical domain". Each software tool is enhanced by applications performed in a virtual & remote laboratory. All products are available at the address: <http://vlab.unitbv.ro/velab/>.

II. GENERAL DESCRIPTION OF THE SOFTWARE TOOLS

All the software products produced in the frame of the project meet the following requirements [3]:

- Using specific interactivity of educational software to obtain a customisation of the teaching / learning process.
- Using software facilities to organize contents in a systematic and interactive way.
- Using demonstration and simulation.
- Using remote experiment.
- Continuing evaluation by self-assessment tasks / tests included in the software.
- Multiple complexity levels of contents are provided, for each software tool, in order to allow a flexible and open access.

All the software products have the same structure, which consists of four parts:

- The user's guide explains the user interface, the navigation buttons, other controls and the colour code
- The course description gives a short presentation by which the objectives, the structure and the target group are presented.
- The overview gives short explanations on each module-course chapter.
- The content allows the access to the module-course content. Each chapter includes the theoretical part and a number of tests that can be solved in a sequential way or randomly.

All products are produced using the dedicated software ToolBook Instructor 8.

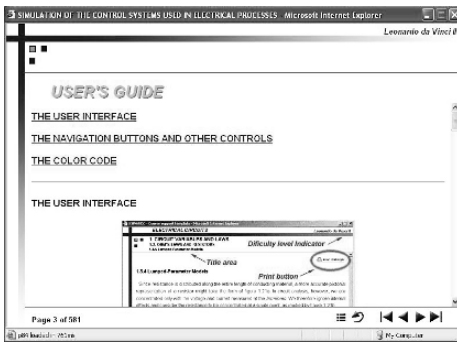


Fig. 1. The User's guide

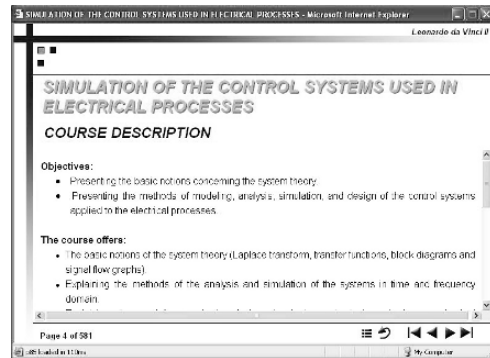


Fig. 2. The course description

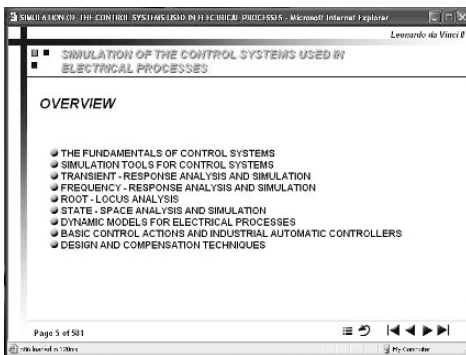


Fig. 3. The overview

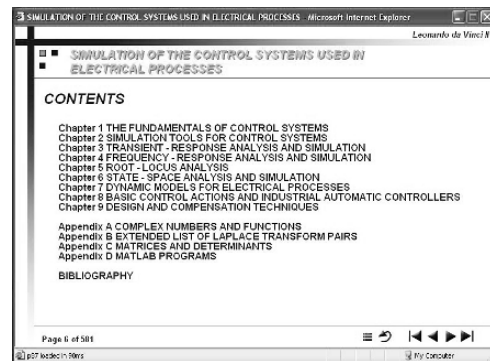


Fig. 4. Control systems module course content.

III. SIMULATION OF THE CONTROL SYSTEMS COURSE CONTENT

The control systems module course contains nine chapters. The chapters' objectives are described below [4],[5],[6],[7]:

Chapter 1 THE FUNDAMENTALS OF CONTROL SYSTEMS

Chapter's objectives: giving the definitions, and knowing properties and theorems of the Laplace transform; knowing the most important Laplace transform pairs; finding rapidly the inverse Laplace transform of a complex function of the variable s ; solving systematically, based on Laplace transform, the linear time-invariant differential equations; determining the transfer function for simple electrical circuits; simplifying complex block diagram using basic rules or applying Mason's formula.

Chapter 2 SIMULATION TOOLS FOR CONTROL SYSTEMS

After studying this chapter the student will know: how the basic expressions in MATLAB are entered; predefined variable and elementary functions in MATLAB; general MATLAB functions; control commands and functions; 2D and 3D plots in MATLAB; how the block diagrams in SIMULINK are realized; the structure of the block libraries of environment SIMULINK; how the data transfer between MATLAB and SIMULINK is realized.

Chapter 3 TRANSIENT-RESPONSE ANALYSIS AND SIMULATION

After studying this chapter the student will be able to: use typical test signals; find time response from the transfer function; use poles and zeros for obtaining time response of a control system; describe qualitatively and quantitatively the time response for first and second order systems; approximate higher order systems as first and second order elements; give definition of time domain specifications; determine time domain specifications for first and second order systems; evaluate control system stability based on closed-loop transfer function; define and obtain the steady-state errors of control systems for different typical test signals.

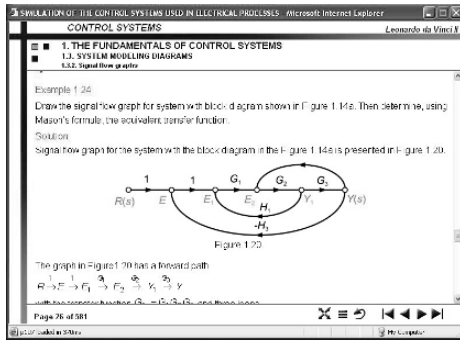


Fig. 5. Page example from the Chapter 1

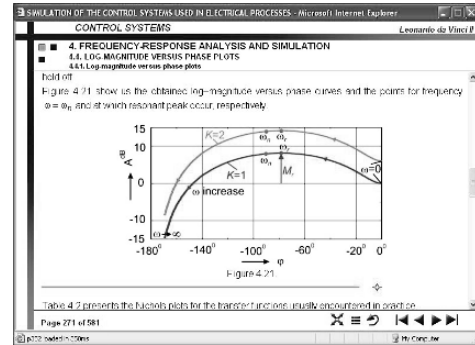


Fig. 6. Page example from the Chapter 4

Chapter 4 FREQUENCY-RESPONSE ANALYSIS AND SIMULATION

After studying this chapter the student will able to: give the definition of frequency response; find the steady-state response to a sinusoidal input using the transfer function; evaluate the frequency response from poles-zeros location; draw the approximate asymptotic log-magnitude and phase-frequency curves based on the transfer function; use log-magnitude curves for evaluating of the steady-state errors; draw the polar plots for the basic factors of the open-loop transfer function; determine quickly the shape of the polar plots starting from a certain transfer function; use frequency-response to analyse stability.

Chapter 5 ROOT-LOCUS ANALYSIS

Chapter's objectives: applying the magnitude and angle conditions for obtaining the location of the closed-loop system poles from the poles-zeros placement of the open-loop transfer function; finding the starting points and terminating points of the root-locus and finding also the number of separate branches of the root-locus; determining the portions of the root-locus on the real axis and the asymptotes of the root-locus; finding the break-away and break-in points; evaluating the angles of departure (or angles of arrival) of the root-locus branches from the complex poles (or to complex zeros); finding the points where the root-locus branches cross the imaginary axis.

Chapter 6 STATE-SPACE ANALYSIS AND SIMULATION

Chapter's objectives: approaching models with state variables; determining models with state variables for electrical circuits and the time response of the state-space modeled systems; performing conversion between state-space and transfer function models and; analyzing the structural properties, controllability and observability of the state-space modeled systems; using MATLAB in state variable models analysis and simulation.

Chapter 7 DYNAMIC MODELS FOR ELECTRICAL PROCESSES

After studying this chapter the student will know: basic elements of passive linear circuits; how to use the Kirchhoff's laws for modeling of electrical circuits; how to use the loop-current method to determine the transfer function of an electrical circuit; how to apply systematically the node-voltages method to solve the modeling problems of electrical circuits; the properties of the ideal operational amplifiers; basic active electrical circuits with ideal operational amplifiers; how to determine the transfer function in some cases of electrical circuits with ideal operational amplifiers; the principle and laws used for modeling of mechanical systems; elements and dynamic models of transactional mechanical systems; elements and dynamic models of rotational mechanical systems.

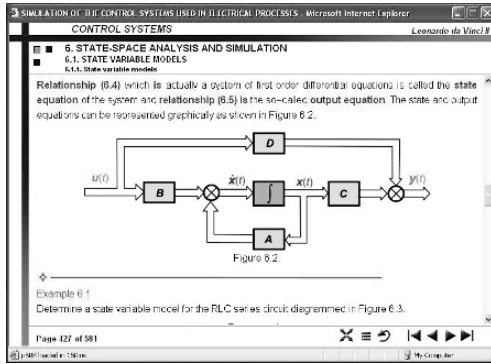


Fig. 7. Page example from the Chapter 6

Chapter 8 BASIC CONTROL ACTIONS AND INDUSTRIAL AUTOMATIC CONTROLLERS

After studying this chapter the student will know: the general structure of a control system; the basic control actions and types of automatic controller; the main characteristics and parameters of the linear P, I, PI, PD and PID controllers; the effects of integral and derivative control actions on system performances; how is reduced the influence of parameters variation by using feedback; the definition of the sensitivity of control systems to parameter variations; typical diagrams used to implement electronic controllers with operational amplifiers.

Chapter 9 DESIGN AND COMPENSATION TECHNIQUES

After studying this chapter the student will know: the effects of the addition of poles and zeros in open-loop transfer function; information obtainable from open-loop frequency response; requirements on open-loop frequency response; the basic characteristics of lead, lag, and lag-lead compensation; the characteristics of lead compensators; lead compensation techniques based on the root-locus approach; lead compensation techniques based on the frequency-response approach; the characteristics of lag compensators; the design procedure for lag compensation by the root-locus method; lag compensation design algorithm based on the frequency response approach; the design procedure of control systems with PI controllers; lag-lead compensation design method based on the root-locus approach; lag-lead compensation design algorithm based on the frequency-response approach.

Course's configuration:

Number of pages: 581, number of figures: 234, number of tests: 141, number of examples: 132, number of appendances: 4.

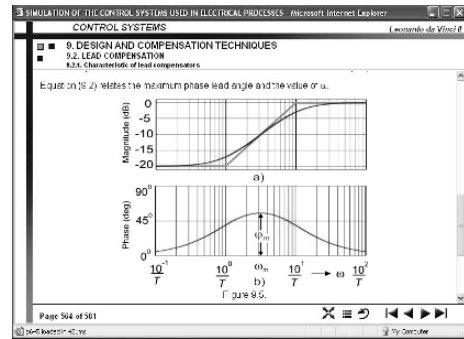


Fig. 8. Page example from the Chapter 9

IV. "CONTROL SYSTEMS" REMOTE EXPERIMENT: *Study of an automatic system that includes an AC motor*

The experimental works include a workbench server dedicated for the control of the stand which contains one AC tested motor and the corresponding electromagnetic brake (a DC motor used like a DC generator) and the electrical load that presets the load for the tested motor.

The requests of the registered clients are sent, through the e-campus server, are further processed by WEB server engine and transferred into a database. The corresponding requests are stored into specific records managed by the MS SQL server. Periodically, the workbench server dedicated for laboratory asks the SQL server about the requested tasks. If requests from clients are stored into the database, with an established priority, the request with the higher priority will be executed with respect to the corresponding work bench [8]. At the same moment, a time-out mechanism will be started in order to terminate the process, if some problems occurred.

All the data results of execution of the experiment will be sent to the SQL server and will be stored into an item of the original record defined for the client's requests. Using a classical mechanism, the client can look at the evolution of the experiment and can receive the corresponding data. At the end of the experiment execution, the client request will be erased from the database and a new request, if it exists, will be sent to the workbench in order to be executed.

Experiment configuration:

- The workbench server: Pentium PC (MS Windows)
- ProfiBus card Hilscher that drives the current inverter
- Altivar 58 electronic inverter to drive the asynchronous motor
- DC generator like a brake
- Load variable resistor

- ATmega128 system that controls the appliance of the load and assures the reliability of the laboratory
- GeMAYSYS data acquisition system, to acquire the most important parameters of the laboratory.

Features:

- Can control the on/off switch for the electrical machines and can allow to run the application
- Can parameterise the ALTIVAR 58 inverter by Profibus card and bus
- Measure the parameters such as: voltage and the current of the asynchronous motor, the voltage and the current of the DC generator
- Control the load on the generator by the PWM method.
- Assure the reliability of laboratory by verifying the condition for start and run of the system

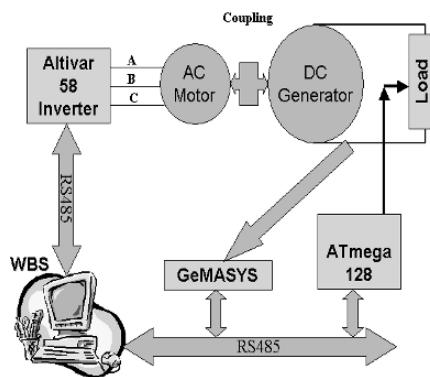


Fig. 9. Block diagram of laboratory

V. CONCLUSION

The presented e-learning tool allows:

- improving the training by increasing the weight of the methods specific to the open & distance learning environment;
- reducing the financial efforts of the educational units through the access to the virtual & remote experimenting resources of the created system; the exploitation costs of virtual laboratories are low and their periodically upgrading allows a great dynamic evolution and reconfiguration of educational resources with minimal financial efforts;
- facilitating the access to education (tutoring, information and experiment), of a wider range of potential users who want to learn from their school,

- Fill a database with the measured characteristics

Operation Mode:

The user must access the <http://vlab.unitbv.ro/velab/> and from here on, if it is a registered user, must follow the links to the corresponding WEB page laboratory.

How the laboratory works?

The PC that represents the workbench server (WBS) interrogates periodically the SQL server. It receives the client requests and initiates the starting of the laboratory that means to execute the parameterisation of ALTIVAR 58, of ATmega128 controller and GeMASYS system. At the same time all the verification of parameters are realized. Finally, the results of laboratory will be delivered to the client.



Fig. 10. ALTIVAR 58 inverter and the AC machine

firm or home, in their free or work time (during reconversion periods);

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Design, Development and Implementation of a Bioinformatics Course Sequence

Gina Cooper

DeVRY University Columbus Campus, 1350 Alum Creek Dr, Columbus, OH 43209
gcooper@devrycols.edu

Abstract - Bioinformatics is emerging as a new and exciting field. Biological data repositories are complex and increasing in size constantly. Manipulating, analyzing, and interpreting this data requires the use of computers and trained biomedical informaticians. Spending on bioinformatics projects has exceeded a billion dollars in the past year and is expected to grow every year. To support this growing need for trained biomedical informaticians, DeVry University has developed a bioinformatics curriculum available to both onsite and online students. This paper provides a context for two of the classes in the curriculum, the course content, labs, and instruction.

taking other courses onsite. To maintain the freedom to mix delivery formats, bioinformatics courses must be flexible in both topics and material covered.

The field of bioinformatics is especially suited to the online teaching environment. Most data is freely available for download and manipulation. Tools for sequence alignment, phylogenetics, visualization, and microarray analysis are open source or freely available online. Table 1 lists a few of the many bioinformatics databases publicly available [2]:

I. INTRODUCTION

Since the completion of the Human Genome project in 2001, several new information technology projects have surfaced. Due to the open source nature of the bioinformatics community, much of the bioinformatics data is available online. This data is constantly being downloaded, manipulated, and analyzed. In addition to data, numerous bioinformatics tools and algorithms are being developed to assist users in efficiently analyzing bioinformatics data. The need for skilled biomedical informaticians is increasing. A search on the Medzilla search site reveals numerous matches for biomedical informaticians who are competent using tools to analyze biological data [1]. The bioinformatics curriculum at DeVry University will prepare graduates to effectively retrieve and analyze biological data. Four courses in the bioinformatics curriculum provide students with the necessary tools to be successful as biomedical informaticians. These courses are flexible enough to be taught in online, onsite, and hybrid online-onsite formats. Two of these courses will be discussed in this paper. These are BMI310 Bioinformatics I with Lab and BMI315 Bioinformatics II with Lab. A third course, BMI325 will follow this sequence and will focus on advanced programming concepts for bioinformatics. Finally, BMI433 represents a capstone course in the curriculum in which students create and document a semester long project for a business.

II. ONLINE BIOINFORMATICS CURRICULUM

Current delivery formats for education can be mixed between online, onsite, and hybrid courses. Students may choose to take some courses towards their degree online while

TABLE 1
Biological Data and Information Sources
Biological Data and Information Sources
Adapted from Gibas and Jambeck Table 6-1

Subject	Source	Link
Biomedical Literature	PubMed	http://www.ncbi.nlm.nih.gov
Nucleic Acid Sequence	GenBank SRS at EBI	http://www.ncbi.nlm.nih.gov http://srs.ebi.ac.uk
Genome Sequence	Entrez Genome TIGR databases	http://www.ncbi.nlm.nih.gov http://www.tigr.org/tdb
Protein Sequence	GenBank SWISS-PROT at ExPASy PIR	http://www.ncbi.nlm.nih.gov http://www.expasy.ch/spro http://www-nbrf.georgetown.edu
Protein Structure	Protein Data Bank	http://www.rcsb.org/pdb
Entrez Structure DB Protein and peptide mass spectroscopy	PROWL	http://prowl.rockefeller.edu
Post-translational modifications	RESID	http://www-nbrf.georgetown.edu/pirwww/search/textresid.html
Biochemical and biophysical information	ENZYME BIND	http://www.expasy.ch/enzyme http://www.ncbi.nlm.nih.gov
Biochemical pathways	PathDB KEGG WIT	http://www.ncgr.org/software/pathdb http://www.genome.ad.jp/kegg

		http://wit.mcs.anl.gov/WIT2/
Microarray	Gene Expression	http://industry.ebi.ac.uk/~alan/MicroArray/
2D-PAGE	SWISS-2DPAGE	http://www.expasy.ch/ch2d/ch2d-top.html
Web Resources	the EBI Biocatalog	http://www.ebi.ac.uk/biocat
	IUBIO Archive	http://iubio.bio.indiana.edu

In addition to the plethora of material available online, there exists a helpful online community where students can benefit from the experience of experts in the field. Molecular biology simulations can also be performed remotely for laboratory experience.

Even with the availability of online databases and tools, challenges exist to the development and implementation of BMI310 and BMI315 in an online delivery format. Following is the discussion of the implementation of these two courses online. The lectures, assignments, labs, discussions and exams enhance learning and provide students with hands-on knowledge to complete their understanding of the topics of the courses.

III. DEVELOPMENT

A. Course Content

The course content of BMI310 Bioinformatics I and BMI315 Bioinformatics II reflect current research and industry trends. Main topics in BMI310 are broad, yet provide enough depth that the students can learn from hands-on projects. Some topics for BMI310 include: the basics of molecular biology, databases and information retrieval, database searches and pairwise alignment, BLAST, FASTA, CLUSTALW, substitution patterns, phylogeny, prokaryotic and eukaryotic genomes, microarrays, protein structure and function, visualization tools such as CN3D, and proteomics and drug design. These topics provide a broad introduction to the field of bioinformatics and impart a good knowledge baseline to the students.

The course content for BMI315 provides more in-depth knowledge in the areas introduced in BMI310 as well as an introduction to Perl programming. This course builds upon the knowledge gained in BMI310. The initial design of BMI315 was a tools class covering online tools such as BLAST, FASTA, CLUSTALW, and CN3D. However, the scope of BMI315 was expanded as students entering BMI325 lacked sufficient programming knowledge in Perl to create efficient and effective programs. Some topics which were added to BMI315 include: molecular biology basics, data structures, Perl programming, UNIX and LINUX scripting, bioPerl, dynamic programming, database homology searches,

genetic algorithms, and neural networks. Due to the additional programming concepts added to BMI315, the online tools topics were moved to BMI310. This design works well as the algorithms for these tools are introduced in BMI310.

This course sequence will provide students with basic and advanced knowledge in bioinformatics. Labs and exercises based on the content of these courses are assigned to encourage learning.

In an onsite classroom setting, these topics would be introduced in a lecture format with demonstrations to reinforce the material to students. The online setting provides an opportunity for the lecture and demonstrations to be combined. Lectures are short narratives using images, links, and flash interactives to convey new information and reinforce it with mini-demonstrations.

B. Textbooks and Content Outlines

Many bioinformatics textbooks are designed for the graduate level classes and therefore contain too many advanced topics to be used as undergraduate text books. Ten textbooks were evaluated for BMI310 with evaluation criteria of: topics covered in the book, sample Perl code, clarity for undergraduate students, homework problems, answers to homework problems, and instructor resources. No textbook contained all topics for BMI310, however one textbook: Fundamental Concepts of Bioinformatics by Krane and Raymer was chosen based on the criteria above [3]. The nine remaining textbooks were listed as recommended textbooks.

Descriptions of each book and their analysis also follow including the text and recommended texts chosen for the course.

Text:

D. Krane and M. Raymer. Fundamentals of Bioinformatics. Benjamin Cummings, 2003. (ISBN 0-8053-4633-3)

This text is written in clear, concise, and understandable language for readers in all disciplines, especially undergraduate students. End of chapter problems increase student's problem solving skills and encourage critical thinking. Answers to odd problems are available in the appendix. The appendix also contains a wide variety of Perl code and examples to aid the students and instructor with example problems. Instructor resources include answers to even-numbered end of chapter questions. However, instructor resources did not contain PowerPoint slides.

Recommended texts:

A. Lesk. Introduction to Bioinformatics. Oxford, 2002. (ISBN 0-19-925196-7).

This text is well written and well organized. It provides end of chapter problems and weblems. The weblems are questions that can be used for extra study and research, however no odd-question answers are provided in the back of the book. This

book has an excellent chapter on information retrieval and provides a good overview of the publicly available databases. This book has very little Perl code.

A.M. Campbell and L. J. Heyer. Discovering Genomics, Proteomics, and Bioinformatics. Benjamin Cummings, 2002. (ISBN 0-8053-4722-4).

This text has many accompanying resources including an instructor's manual and CD. The text is clearly written and includes mathematical equations "Math Minute" to encourage the reader to apply mathematical problems to biology. No end of chapter questions are included, however Discovery Questions are provided throughout the chapter. No Perl code is used.

J. Setubal and J. Meidanis. Introduction to Computational Molecular Biology. PWS Publishing Company, 1999. (ISBN 0-534-95262-3).

This text is written at the graduate level as an introduction to bioinformatics. Even though it is designed for an advanced audience, the text is easy to understand and contains several good examples.

T.K. Atwood and D.J. Parry-Smith. Introduction to Bioinformatics. Prentice Hall, 1999. (ISBN 0-582-32788-1)

This text is written in light, simple language and is easily understandable. It uses figures and metaphors to further explain detail to the reader. No end of chapter problems or Perl code are provided.

H.H. Rashidi and L.K. Buehler. Bioinformatics Basics. CRC Press, 2000. (ISBN 0-8493-2375-4).

This text has an excellent chapter about the online databases available. It shows in hierarchical form where databases are and how to access these databases. It also has an interesting chapter on neurobiology and mapping the human brain. No Perl code is provided.

B. Bergeron, Bioinformatics Computing. Prentice Hall, 2003. (ISBN 0-13-100825-0).

This text provides a wide overview of the field of bioinformatics. Unlike many other texts, this book has a chapter on statistics, networks, data mining, and pattern matching. It does not have end of chapter problems and few examples, but it has good explanations on a variety of topics.

P. Bourne and H. Weissig. Structural Bioinformatics. Wiley-Liss, 2003. (ISBN 0-471-20199-5).

This text is written at a graduate level with a fair amount of complex mathematics. It includes details about protein interactions and structure prediction not found in many other texts.

H. Motulsky. Intuitive Biostatistics. Oxford Press, 1995. (ISBN 0-19-508607-4).

This text is written for the user of statistics. It explains statistics in a clear manner with examples pertaining to bioinformatics. This text includes end of chapter problems and is a great additional reference.

D. Jamison. Perl Programming for Biologists. Wiley-Liss, 2003. (ISBN 0-471-43059-5).

This text is written for biologists learning to do programming so the examples and explanations are very clear and understandable. It includes good end of chapter problems, and even introduces bioperl.

BMI315 will build upon the knowledge of BMI310 and will introduce programming concepts. The Krane and Raymer book contains beginning Perl explanations as well as assignments. A supplemental book for BMI315 was chosen to introduce tools for bioinformatics. This text is Developing Bioinformatics Computer Skills by Gibas and Jambeck. This text focuses on tools available for bioinformatics but lacks homework problems.

As the field changes, textbooks will adapt and may eventually be offered in e-book format. E-book format is useful for online students however the current textbooks are not offered in this format.

A content outline describing the topics covered for both BMI310 and BMI315 is listed below. While there are considerably more topics in BMI310 than BMI315, both courses can be reasonably taught in an eight week accelerated format or a fifteen week standard course format. These topics will lay good foundations for the field of bioinformatics and bioinformatics programming.

BMI310 Content Outline:

- I. Introduction
- II. Molecular Biology
 - A. Genetic Material
 - B. Central Dogma
 - C. Gene structures
 - D. Chemical bonds
 - E. Proteins
- III. Pairwise Alignment and Database Search
 - A. Dot plots
 - B. Simple sequence alignments
 - C. Gaps
 - D. Scoring Schemes
 - E. Dynamic programming
 - F. Multiple sequence alignment
 - G. Database Search
- IV. Multiple sequence alignments
- V. Substitution Patterns
 - A. Mutation rates
 - B. Estimating substitution numbers
- VI. Phylogeny

- A. Phylogenetic trees
- B. Distance based methods
- C. Character based methods
- D. Comparison of phylogenetic methods
- VII. Genomics
 - A. Prokaryotic genomes
 - B. Eukaryotic genomes
 - C. Open reading frames
 - D. Gene expression
- VIII. Protein structure
 - A. Amino acids
 - B. Secondary structure
 - C. Tertiary and Quaternary Structures
 - D. Algorithms for modeling protein folding
 - E. Structure prediction
 - F. Prediction of protein function
- IX. Proteomics and Drug Design
 - A. Protein classification
 - B. Experimental techniques
 - C. X-Ray Crystal structures
 - D. NMR structures
 - E. Ligand screening
 - F. Lead compound
 - G. Computer-assisted drug design
- X. Visual representation

BMI315 Content Outline

- I. UNIX/Linux
 - A. UNIX commands
 - B. Shells
 - C. Pattern matching
 - D. The vi editor
- II. Bioinformatics data
 - A. Data Formats
 - B. Retrieving data
- III. Perl programming
 - A. Variables
 - B. Calculations
 - C. Arrays
 - D. Hashes
 - E. Control Structures
- IV. Perl String Manipulation
- V. Databases and Information Retrieval
 - A. Write programs to analyze data from:
- VI. Perl subroutines and functions
- VII. Statistics
 - A. Confidence Intervals
 - B. P Values and their significance
 - C. Bayesian logic
 - D. Statistical tests
 - E. Unpaired t Test
 - F. Paired t Test
 - G. ANOVA

- H. Choosing a test
- I. Write Perl code to calculate statistical parameters
- J. Use Matlab to compute statistical parameters
- K. Use PubMed to find articles using statistical parameters
- VIII. Matlab's Bioinformatics Toolbox
 - A. Microarray data analysis
 - B. Sequencing analysis
 - C. Mass spectrometry

C. Labs and Assignments

Labs and assignments in both BMI310 and BMI315 must complement the material introduced in the lectures and reading in the course. While choosing labs, careful consideration must be made that the labs can be done by students in onsite or online delivery formats, and that these labs and assignments enhance learning and provide the students with hands-on knowledge to complete their understanding of the topics they have learned.

Every week a homework assignment consisting of problems from the chapters of the book is assigned. Students complete the assignments in a word processing document and submit them electronically.

Labs are assigned based on the topics covered. BMI310 introduces students to the topics in bioinformatics, and the labs focus on a variety of these topics. The first lab focuses on molecular biology tools. NeoSci Corporation has developed several lab investigations as simulations that can be easily performed over a Citrix network. The first lab assignment in BMI310 involves a lab investigation of "Restriction Enzyme Cleavage of DNA and electrophoresis". This gel electrophoresis simulation is complete with Agarose Gel, sample DNA, pipettes, and a lab notebook (Figure 1). Students are guided through the simulation to perform the gel electrophoresis. Once complete, students measure each sample and mark their results in a lab notebook which can be printed or saved to submit for grading.

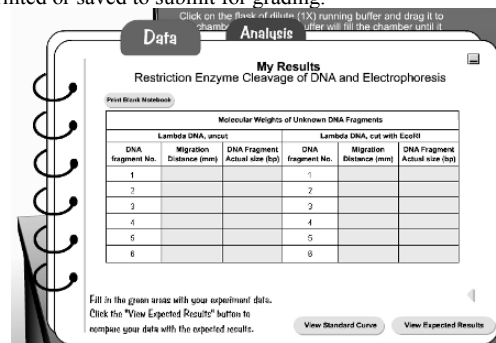


Fig. 1. Lab Notebook from NeoSci Lab Investigation

Using this online simulation through Citrix, students can participate in a distance learning laboratory setting without the need for a wet lab. In an onsite setting, an actual gel electrophoresis experiment can be performed to provide the students with laboratory experience; however onsite classes can also take advantage of the Citrix environment and use the simulation. The second lab guides students through the process of downloading data in specific formats (FASTA, pdb, etc.) from a variety of online databases. Students then review these files and formats and answer questions based on the particular files. Lab 3 involves performing a nucleotide BLAST search on cold shock protein in *ecoli*. Lab 4 uses online tools to perform a phylogenetic analysis. Lab 5 uses the NCBI (National Center for Biotechnology Information) site to find a region of the cow (*bos taurus*) that contains a region homologous to a human chromosome region. Finally, lab 6 gives students an opportunity to use clustering and Pearson correlation coefficients to group results from microarrays (see full description below).

Lab 6: Microarray data mining

Procedure:

- Below are gene expression readings. Each row consists of the gene expression readings of different genes at different time points.

Gene	0 hours	2 hours	4 hours	6 hours	8 hours
GeneA	0	3	4	3	3.7
GeneB	0	1.88	2	2	1
GeneC	0	0	0.25	0	1
GeneD	0	2	3	2	2
GeneE	0	0	0	0	1.59
GeneF	0	3	3.68	3.59	3

- Measure the similarity between the responses of the genes based on the Pearson correlation coefficient for each pair of genes.
- Which genes are closely related? Which genes are not closely related?
- Cluster the gene order based on similarity of expression patterns. Use hierarchical clustering to determine your answer.
- Show how you determined which genes were clustered and their coefficients.

BMI315 requires more in depth assignments using Perl and Unix. Students need a Unix or Linux machine to which they can log into and perform commands and operations. A server has been installed for remote use by the students. Each student has an account and can store data as well as create perl programs. In BMI315, students are introduced to biostatistics and use the Matlab Bioinformatics Toolbox to solve statistical problems on genes. The Matlab Bioinformatics Toolbox can be accessed using Citrix over a network. Thus the students

can finish labs and assignments without installing Matlab on their personal computers.

D. Discussions

In online courses, students are required to participate three times a week in online threaded discussions. Threaded discussion questions must be open ended to encourage dialogue with the other students in the course. Two threaded discussion questions per week are graded, while the third required weekly post utilizes a forum for questions on assignments that is not graded. When students respond to others posts, the instructor acts as a facilitator, sometimes asking additional questions to further discussion. Discussion questions can be open ended questions about the lecture or can include an assignment instructing the student to research information on the internet, post their results, and comment on others posts. Some examples of discussion topics used in BMI310 and BMI315 are listed below:

- Based on your knowledge of the central dogma of biology, what types of mutations will not affect the proteins produced? Can some mutations be beneficial?
- Most genetic disorders are a direct result of the mutation of one gene. Go to this site: <http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowSection&rid=gnd.preface.91> And pick a chromosome, then pick a disease on that chromosome. Research the disease on NCBI's OMIM site, or on the web and write a one page description about it (especially noting any mutations mentioned in the literature). Attach this document to your discussion.
- We have discussed different scoring methods used when creating alignments. Introduce a different scoring mechanism and discuss the benefits of it (example: weighting gaps differently, matches and mismatches weighted the same, etc),
- Right now, doctors prescribe medicine based on the disease; what implications may occur if doctors could write a prescription based on your genetic makeup? How will knowing information about an individual's gene expression patterns minimize unwanted side effects of prescription drugs?
- One of the mantras of the Perl programming language is "there's more than one way to do it". Do you think this is true? Can you come up with several ways to do looping for example?

E. Testing

Due to the nature of an online course, tests can be challenging and give students an opportunity to research answers. BMI310 covers a wide variety of material and thus matching, multiple choice, and some short answer questions are suitable for the final. As BMI315 delves deeper into bioinformatics and focuses on programming, essay questions

are best for its final exam. For both courses a question pool is used to vary questions per student.

F. Student Feedback

Prior to the final exam in both BMI310 and BMI315, students were given a feedback assessment form. This form queried the students on their level of competency in the terminal course objectives and asked for comments about improving the course. Students rated their understanding of each topic from 1 (Poor) to 4 (Excellent). Student feedback forms from BMI310 noted that the topics they were most comfortable with were the central dogma of biology, online searching with BLAST, and global and local alignments which received average scores of 3.17, 3.33 and 3.17 respectively. Students expressed difficulty with phylogenetic trees and protein folding models each of which received scores of 3.0. To improve the student's knowledge level with these topics, a more challenging lab has been developed and will be implemented in future BMI310 courses.

In BMI315, students' responses indicated that they had a greater comfort level with the programming topics than the statistics topics. Average student scores were 3.86 for reading data from a FASTA formatted file using Perl and 3.71 for both Perl programming and regular expressions. Average scores for statistical knowledge as well as comfort with using the Matlab Bioinformatics toolbox were 3.57. Additional exercises and examples will be added to improve student knowledge in statistics.

IV. CONCLUSIONS

Genomic databases are increasing in size very rapidly. Trained bioinformaticians are needed to access and manipulate this data. BMI310 Bioinformatics I and BMI315 Bioinformatics II will create graduates with these skills, and using a distance learning format will open accessibility to the program to anyone with internet access. The course content introduces basic and advanced topics in bioinformatics to students. Labs, discussions, and exams give students an opportunity to test and share their knowledge in the online format. Following these courses is BMI325, an advanced programming course and BMI433, a capstone course. BMI310 and BMI315 will prepare students for these rigorous final courses. BMI310 and BMI315 are flexible in their design such that they can be taught in onsite, online or hybrid formats. These two courses will provide an excellent basis for the bioinformatics student.

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An online 3d virtual learning environment for teaching children Mathematics

H. Mpouta, F. Paraskeva, S. Retalis, *University of Piraeus – Department of Technology Education & Digital Systems., Greece* xmpouta@unipi.gr

Abstract—Structuring and organising an advanced online collaborative learning environment (CSCL) is the object of this research. The way it can be integrated in the classroom and the curriculum is related to the vision of every reform that aims at improving education. Most of the existing 3d virtual worlds do not combine learning benefits, development of advanced learning and communicative skills, as well as substantial involvement of both students and teachers in the learning process. At first, the theoretical background of the structure and organisation of our world is given. Then, a description is given of the general characteristics of Active Worlds software that was used, along with a brief description of the structure and characteristics of the 3d virtual environment that is being constructed to support the teaching of Mathematics in primary schools. The expected outcomes and proposals for future utilization follow.

Index Terms—online collaborative learning environment, cognitive apprenticeship

INTRODUCTION

There are many 3d virtual environments which aim at the accomplishment of educational goals. These environments promise new learning experiences, which manifests that they are going to become a significant potential in the education domain. Many 3d-centered multi-user tools and technologies are available today, the most significant of them being: blaxxun platform (www.blaxxun.com), Bitmanagement solution (www.bitmanagement.de), Active Worlds (www.activeworlds.com), Octaga (www.octaga.com), Sense8 (www.sense8.com), ParallelGraphics' solution (www.parallelgraphics.com), SmartVR's SmartVerse (www.smartvr.com). [6]. Moreover, many VR applications, such as Web Talk [3], [4] and Shrine Education Experience (SEE) project [12] have tried to provide socializing and manipulation in the virtual world. Nevertheless, it remains questionable whether they are really educationally beneficial for their users.

According to research, there is considerable use of 3d virtual environments as educational tools in the classroom in many subjects, such as History (Maloney, 1997), Biology (Allison et al., 1997), Physics (Dede et al., 1999), Astronomy (Barab et al., 2000), Chemistry (Ferk et al., 2003). Up to date, more and more VR systems have been developed in this direction in order to facilitate learning activities.

Appropriate and responsible use of technology in everyday teaching practice is considered essential, as it can facilitate and support the learning process of Mathematics [23]. Structuring and organising advanced online collaborative learning environments (CSCL) is a basic objective of the research community [26]. The way they are integrated in the classroom and the curriculum seems to be related to the visions of every reform that aims at the improvement of mathematical education. Virtual learning environments are typical of modern educational technology offering multiple possibilities and challenges [24]. However, most of the constructed virtual worlds neither combine learning benefits, development of advanced learning and communicative skills, nor do they practically involve learners and teachers in the learning process. Many researchers [10], [5], through the cognitive apprenticeship model, suggest that knowledge can be better acquired in learning environments which typically include authentic context, authentic activities, modelling of processes, multiple roles and perspectives, collaboration to construction of knowledge, coaching and scaffolding materials for the development of skills and the completion of increasingly difficult tasks, reflection, opportunities for accurate articulation which indicates that knowledge has been mastered, as well as opportunities for integrated assessment of learning tasks [9], [10], [17].

The apparent influence of the Socio-cultural Theory of learning, Vygotsky's Zone of Proximal Development -ZPD, the Situated Cognitions theory and Traditional Apprenticeship [15] on Cognitive Apprenticeship enables us to outline the theoretical framework of the structure and organisation of a 3d collaborative learning environment which could be able to be utilized in everyday teaching practice.

According to the Socio-cultural Theory, the acquisition of knowledge is the result of a historical-cultural process [13]. Human development and learning are created and fostered by the social and cultural interaction within a context defined as "Zone of Proximal Development" [25]. The Zone of Proximal Development is the gap or the area between actual and prospective development. This area is characterized cognitive apprenticeship [9]. Based on the socio-cultural theory, situated learning refers to cognitive processes situated in natural and social contexts [16]. Cognitive processes are concerned with "enculturation" (a kind of mental or cultural subjugation) through the adoption of rules, behaviours, skills, attitudes, language and stances of a particular [20]. It is worth noticing that the basic dimensions of situated learning are:

Context. Knowledge is interconnected and deployed within the context in which learning is realised [7].

Authenticity. Authenticity in education means consistent, natural, meaningful and purposeful activities representing everyday practices [8]. Everyday knowledge not only stresses the nature of the solution of problems of everyday cognitive activity, but also stresses the level of social interaction with others.

Activity & Participation. Knowledge building results from activity [18]. The activity theory [21] is of central importance in the international literature of situated learning. It claims that conscious learning and activity are absolutely intermingled and interdependent. Learning appears as a social regulation through dialogue in the community [19]. It is a process of reflection and negotiation among the participants in the community. *Community of practice.* The aim is the legal peripheral participation in the contexts of the communities of practice [20]. Through the community, trainees interpret, illustrate and form the meaning of concepts. *Shared or distributed cognition.* The theory of distributed cognition claims that knowledge is not in the mind of trainees, but it is distributed in the world among the individuals, the tools, the objects and the books they use, as well as the world of the communities and the practices in which they participate.

Apprenticeships have proved to be an effective form of education. The apprenticeship system often includes a group of trainees, who become resources for one another by exploring an area and helping one another. In the context of cognitive apprenticeship, new technologies can become powerful pedagogical tools [15]. The cognitive apprenticeship approach can be used as a solid foundation for educational design of environments based on computers (i.e. CSCL) either with the use of multimedia or hypermedia or web-based or any other technological systems.

In the following chapters we will describe the general characteristics of the ActiveWorlds software we used and we will give a brief description of the structure and characteristics of a 3d virtual environment that we constructed in order to support the teaching of Mathematics in primary schools. The expected outcomes and proposals for future utilization will follow.

THE BASIC CHARACTERISTICS OF OUR PROPOSED 3D WORLD AND THE POSSIBILITIES OF UTILIZING IT IN THE EDUCATIONAL PROCESS

The basic object of our research is the structuring and organising an online 3d collaborative world, dynamic and innovative so that it will motivate collaboration and learning, will lead to learning benefits as well as to the development of advanced learning skills via synchronous / concurrent or asynchronous / non-concurrent, interactive and collaborative situations. We also aim at this world to function in combination with or as a supplement to everyday traditional teaching practice, implementing it in the subject of Mathematics, but in an inter-curricular manner as well. To achieve that, we utilize the possibilities of Active Worlds

software combined with the principles of the cognitive apprenticeship model in relation with learning environments.

Active Worlds software offers various possibilities of creating a complete online 3d collaborative and virtual world, depending on the goal set each time. In general, it offers 3d space where you can "build" your own world, in which the builder can surf using avatars. Avatars are visual representations of the individuals in the virtual world selected from the avatar menu. They can make gestures (i.e. greeting, expressing emotions) and move just like in the real world. When the user enters the virtual world, the Web Browser is activated simultaneously, and you can build your own web site system. The possibility of direct and indirect communication among users is also a very important function active worlds. Users can communicate in writing and directly via the chat window (a communication window which in the basic monitor of the world), but also via whispering (an operation used for more personal communication among users). Indirect communication is achieved through the telegram operation, even when individuals are not present in the world at the same time.

The virtual world we construct (Illustration 1) in order to support primary school teaching in the subject of Mathematics meets the challenges of virtual learning environments, as these are reinforced by the principles of cognitive apprenticeship [10], [5] in combination with the possibilities of active worlds software.



Illustration 1: screen shot to the virtual world in ancient Cairo

Simulating the social learning process [18] and the social dimension of Mathematics, we enrich our world with authentic activities which demand a collaborative attitude, so that our students will encounter real-word problems. A travel agency organises innovative holidays and the students are asked to travel to various places and times, to ancient Cairo, ancient Greece, even into the future! Throughout their

adventure they encounter in authentic contexts. For example, they need to budget their travels, they need to help people they meet (i.e. the tavern owner in Cairo who has to calculate how many griddles of cheese pie he must prepare for his customers, the fabric seller who must figure out how he must cut the fabric, etc). At the same time they realise that mathematical problems are part of everyday life in various societies, regardless of the historical period. They are also able to discover cultural components of various civilizations (i.e. through the riddles of the Sphinx on the banks of the Nile etc.).

The students have access to feedback from experts and scientists, since they can communicate, discuss with them and ask for their help (i.e. their teacher or an expert in historical and cultural matters or in History of Mathematics), through the use of videos, simulations and the Internet.

Our world may produce scenarios that offer opportunities for coaching and provides scaffolding materials for the solution of increasingly complex problem-solving activities. Scaffolding allows the students to participate in complex cognitive activities [18].

Additionally, our world, based on the cognitive apprenticeship model, offers flexibility and interaction in contrast with traditional books. Trainees are given the additional opportunities to reflect on their learning [17], since they have to use their knowledge in effective ways. In this way, they gain the experience of a deeper understanding [18] and opportunities for meta-cognition.

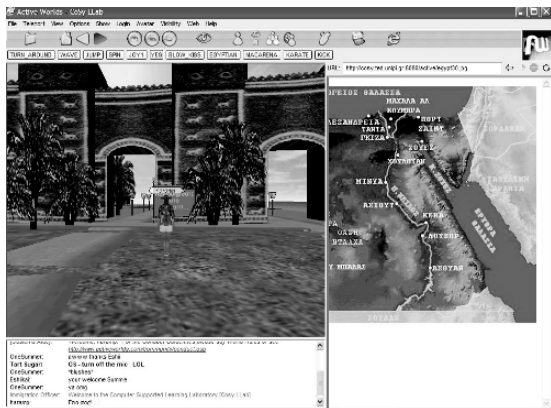


Illustration 2: screen shot of the virtual world in ancient Cairo

All the activities demand that students be placed in groups, since learning is achieved through collaborative action among the members in a community of practice [20], and therefore they demand a deep sense of collaboration and competition.

EXPECTED OUTCOMES – FUTURES UTILIZATION

The virtual world we propose aspires to meet the demands and objectives of the Unified Inter-Curricular context of

studies for the subject of Mathematics in primary level (by fostering the mathematical language as a medium for communication, developing problem-solving skills, demonstrating the possibilities for implementation and practical use of Mathematics, nurturing a positive attitude towards Mathematics, etc.), Information Technology (by utilizing Information Technology tools, communicating and information seeking in the Internet, etc.) as well as Drama (by taking roles in the group each student belongs to and by creative expression, collaboration, harmonious integration in the group, realisation of the meaning of the role, collective art creation, direct activation, the student's participation and intervention in the learning process, productive interconnection of cognitive subjects and combination of theory and practice) (Illustration 2).

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The Concept and Strategy of ICT Integration in Teaching and Learning Process at Bina Nusantara University – Jakarta

Dr. Harjanto Prabowo
Lecturer and CIO - Bina Nusantara Jakarta
harprabowo@yahoo.com

Abstract

This paper discusses ICT integration in teaching and learning process at Bina Nusantara University (UBiNus). The presentation starts with an introduction clarifying background of ICT implementation in higher education, e-Learning definition and implementation models, and the internal factors that supporting UBiNus to integration ICT for teaching and learning process. Next, clarification of Multi Channel Learning Model designed for classroom activities, e-Learning activities, and self study. Initiatives policy describes class meeting, course materials, content development team, teaching certificate, and scoring policy. Programs related to MCL preparation for both lecturers and students, units, and IT supports are presented. The paper also discusses Learning Management System (LMS), infrastructure condition, and performances that will be achieved. It is concluded that ICT implementation in Bina Nusantara University supports not only administration and management activities, but also in teaching and learning activities.

Keywords : teaching and learning, multi channel learning, ICT integration

I. INTRODUCTION

The rapid development of ICT affects the development of technology implementation in every aspect of life, from business, entertainment, socials and education especially. The benefit of ICT's role in education had been realized since 1990's, along with the declining price of PC, the widespread of internet access, the increasing of IT application in the documentation functions, and the availability of animation processing software development.

In its early application, ICT in education had been commonly used to support administrative works and services in universities, in which the main goals were efficiency and better quality services for students. Today, ICT has been used to support the core function of a university, that is learning activity. In other perspectives, ICT application in university is encouraged by a change paradigm in the process of learning, that is from Teacher Centered Learning becomes Student Centered Learning or Student Active Learning, and also from broadcasted learning becomes interactive learning.

The definition of e-Learning can be stated as "The use of network and multimedia technologies to improve the quality of learning by enabling access to knowledge and

remote resources for the development of K-society" [1]. Another definition, e-Learning as "The continuous assimilation of knowledge and skills by adults stimulated by synchronous and asynchronous learning events, and sometimes knowledge management outputs, which are authored, delivered, engaged with, supported and administered using internet technologies" [1], [5]

According to Nagy [9] e-Learning refers to learning that depends on or is enhanced by electronic or online communication using the latest information and communication technology, and according Development Gateway [2] is the application of ICT in support of distance learning, self-guided learning and the traditional classroom

There are 4 pillars to support e-Learning : infrastructure, content, professional/ human resources and policy, "unpublished" [6] as shown in Figure 1.

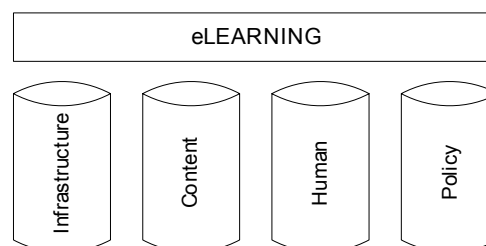


Fig. 1. Factors supporting e-Learning

Bina Nusantara University (UBiNus) is located in West Jakarta and has more than 23.000 students, grouped into five faculties, namely Faculty of Computer Science, Faculty of Economics, Faculty of Maths, Faculty of Engineering, and Faculty of Letters. Those faculties will be developed in the near future.

Along with UBiNus vision : **To become a leading IT-based education institution, accepted as the benchmark for other universities, as well as ready for competition and adaptable to global change**, ICT applications get a full support from parent organization, the directors, and all academic groups, such as students, lecturers, researchers, and staff. ICT implementations had not only for supporting administrative, services, and managerial activities, but also for teaching and learning

activities since the year of 2000 which was called Multi Channel Learning (MCL).

Based on the mentioned introduction, this paper discusses many supporting factors in ICT integration in teaching and learning process at Bina Nusantara University.

II. THE ICT INTEGRATION IN TEACHING AND LEARNING PROCESS

Internal factors supporting ICT integration in teaching and learning process in UBiNus are: (1) Historically, UBiNus had started its market position as a Computer College, therefore, at present, most of the students (70%) are studying in Computer Science, and they have no difficulties in using ICT, (2) most of lecturers already master basic computer and if they have not mastered, they still have opportunities to improve their computer ability and skills in UBiNus, (3) ICT facilities in UBiNus are complete, because since the beginning UBiNus has prepared ICT implementation to support education activities ;(4) UBiNus has a special unit namely IT department with the main job to develop and maintain IT operation for 24 hours and 7 days in a week.

The long road of ICT implementation in teaching and learning process can be seen from the figure 2 below.

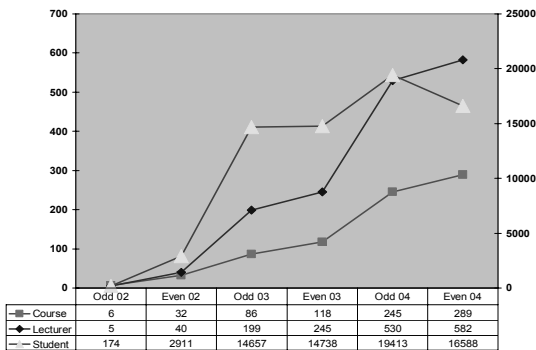


Fig.2 : The ICT implementation in UBiNus (2002-2005)

UBiNus has been using Hybrid Online Model as the integration of ICT in teaching and learning process (figure 3) . The Hybrid Online Model that translate to Learning System which is called Multi Channel Learning (MCL).

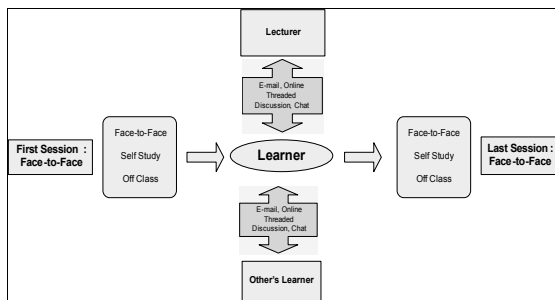


Fig. 3: The Hybrid Online Model

Multi-Channel Learning (MCL) is Binus Learning System. MCL combines several channels of learning, such as: Face to Face (F2F), Self-Study, and E-Learning/ Online Learning (Off-Class/ OFC). Since 2001 the MCL evolution was started very slow and gradual every semester but in the last of 2005, all subjects have become an "MCL Ready course".

The major goal in implementing MCL is to transform students learning culture and habits. We believe that Binusian should be ready to learn everything new everyday, especially in Information Business.

Even though ICT implementation in UBiNus has started many years ago , the system integration has just done in 2000 by the development of Multi Channel Learning (MCL) model (Figure 4).

MCL model dedicated for students and lecturers consists of three activities, they are: (1) Classroom activities, (2) e-Learning activities, and (3) Self Study. Classroom activities present some activities, like tutorials, student presentations, discussion, laboratory study, and invited guest lecturers. Activities for e-Learning are downloading materials, access to digital library, access to online resources, e-Discussion / forum discussion, access to student / lecturer portfolio. Self Study, using e-book for self-learning, Computer Based Training (CBT), and study groups & assignments.

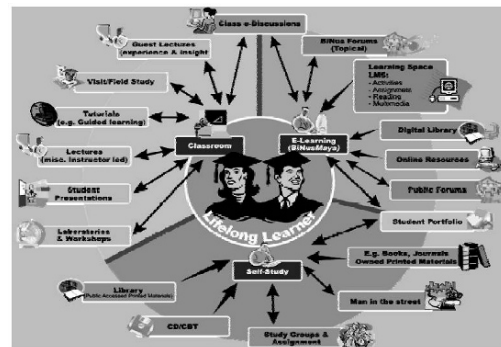


Fig. 4 Multi-Channel Learning (MCL) Model

III. INITIATIVE AND PROGRAMS

UBiNus has some initiatives to be conducted in relation to the policy in ICT integration in teaching and learning activities , they are :

- 1) Number of Class Meeting
Previously, there were 13 sessions of face to face meeting per semester. These 13 sessions are now divided into 70 % (10 sessions) in classroom activities and 30% (3 sessions) in non classroom activities by using the e-Learning facilities.
- 2) Course materials
Course materials for each course consists of : Syllaby (SAP), Modul Plan (MP), Text Book (minimal 1 book), Course Outline (Lecturer notes / presentation, online readings, multimedia / animation, assignments, case study, etc).
- 3) Developing Content Development Team

Subject Experts(SME) are developed for each course and they are supported with facilities..

- 4) Publishing MCL System Teaching Certificate
The Teaching Certificate is for lecturer who has joined the training and succeeded in teaching test/examination,
- 5) Changing the Scoring System
Previously, students' scoring only consists of exams and assignment scores. Now, the scoring has been added by scoring some student activities, such as discussion and student portfolio, etc.

According to the initiative policy, there are several programs to support lecturer and student preparation in MCL system implementation.

- a. Developing Learning Supporting Unit:
There are several units that support MCL preparation and operation, those are :
 - Learning Resources Center (LRC), The unit prepares lecturer in training how to teach, gives MCL system socialization, provides computer facilities, and free internet access.
 - Instructional Development Center (IDC). The unit : helps lecturer in developing digital content (course outline), especially for presentation material, multimedia, animation, etc.
 - E-Learning Center (ELC). The unit helps lecturer in operating MCL system, especially for e-Learning activities.
- b. SME Development
The training is for lecturer comprising these materials: e-Learning methodology, Adult learning systems, e-moderating strategy, Basic Information Technology, Using LMS and CMS.
- c. Content development
This activity is conducted by lecturer team with the following activities :
 - Developing SAP and MP which is supported by LRC and library units.
 - Collecting course material, such as case study, online reading (reference from internet), making student assignment, supported by library unit.
 - Develop multimedia material which is supported by IDC unit.
 - Put all learning materials in the Course Outline format through Content Management System (CMS) facilities.
 - Use the ADDIE concept to develop digital content (see figure 5)

- d. LMS and CMS Development
 - Previously, UBiNus applied Learningspace software (Lotus Products) Learning Management System (LMS) and Content Management System (CMS). After 2 years implementation it emerged several problems, therefore, since 2003 UBiNus had tailored their own LMS and CMS by Microsoft DotNet technology (web- base).
 - The implementation of LMS can be accessed through binusmaya.binus.ac.id
- e. IT Infrastructure Development
Some activities that have been conducted are :
 - Adding internet bandwidth from 2 MHz to 8 MHz.
 - Developing network infrastructure (ADSL and Wifi) for student housing within the radius of 5 km from Binus campus. By this facility students can freely or paying cheap price to access internet facilities.
 - Developing internet access point through wifi in campus (hotspot model).
 - Installing some computer desktops in lecturer room, public access computer rooms, and library for students and lecturers.
 - Supporting students and lecturers to have their own computer (desktop or laptop).
- f. User Training and Socialization
 - Conducting LMS training and socialization periodically for students. This activity involves digital content preparation that will later be implemented.
 - LMS training is conducted in computer laboratory, each student gets training materials, name account, and password to access MCL and digital library. .
 - MCL Socialization is also conducted through seminars and workshop in which students and lecturers are the main participants.
 - Every years, freshmen students have to join MCL system training, including LMS.

IV. LEARNING MANAGEMENT SYSTEM (LMS)

Looking at e-Learning experience from learner's point of view, e-Learning appears as, " Combination of the following elements; log on process, registration process, personal profile, competency and skill assessment, course catalogues, and online courses." [8]

UBiNus have developed LMS to support e-Learning system as part of MCL system. LMS can be accessed from binusmaya.binus.ac.id. BeeLMS front page will ask user account and password. The status (role) will presents 2 kinds of appearances, STUDENT-DESK (for student LMS), and LECTURER-DESK (for lecturer LMS).

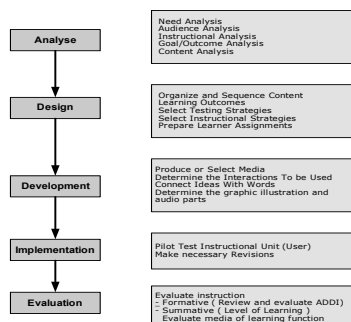


Fig. 5. ADDIE Concept



Figure 6 : BeelMS Home Interface

Student-desk front page can be seen in Figure 7.

Left side of Student-desk front page indicates that LMS provides facilities for students, such as MyClass that contains time table, class, and text book. There is also information services that facilitate access (academic administration and student tuition).



Figure 7 Student-Desk

Lecturer-desk front page can be seen in Figure 8,

Lecturer -desk which is developed has LMS facilities (MyClass) and information service access (lecturer academic administration).



Figure 8 Lecturer-Desk

BeelMS presents complete features, in MyClass student or lecturer can access: Schedule agenda and modul plan; download for lecture material (presentation files), material support, video animation, and assignment; Discussion forum between student and lecturer; Upload answer of the assignment (for student); Summary of student assignment (for lecturer); and Upload extra assignment (additional materials) by lecturer.

Figure 9 and 10 show part of BeelMS features.

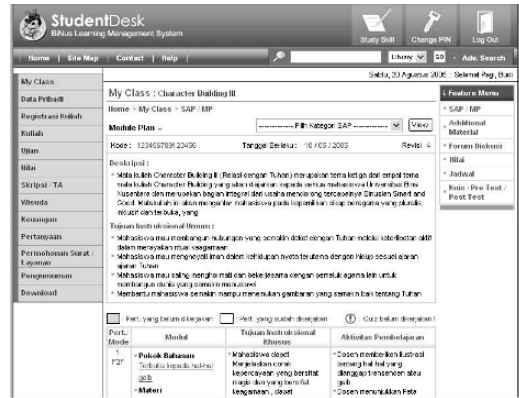


Figure 9 Feature of BeelMS

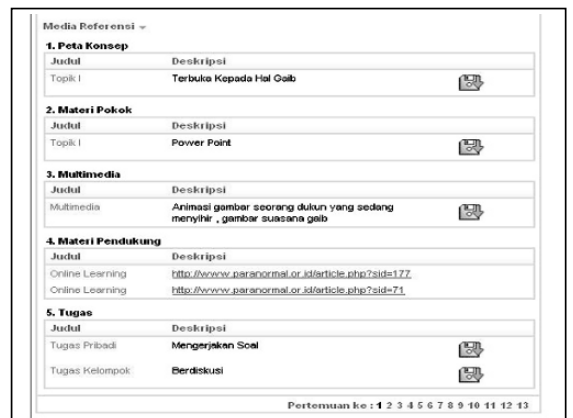


Figure 10 Feature of BeelMS (2)

V. EVALUATION OF TEACHING AND LEARNING PROCESS

The evaluation of Teaching and Learning Process in Bina Nusantara is held regularly for every semester. IKAD which is abbreviation from Lecturer Academics Performance Index contains of eight (8) components of observation , namely (1) the understanding of material; (2) the achievement of material with Learning Outcomes; (3) Varied Example; (4) Task/Exercise; (5) Discussion; (6) Classroom environment (7) Time Usage ; (8) Motivation

The data has been divided into two periods. The first period, which is called N-5, is the data that has been gathered from 5 semesters before the implementation of MCL which is from Semester Odd 1999 until Odd Semester 2001. The second period, which is called N+5, is the data that has been gathered from Even 2001 until Even 2003.

Table-1: First and Second Period of Data Gathering (Number of Students involved in the participation of IKAD Gathering)

Semester	N# of Student
9901	5345
9902	972
0001	1383
0002	1091
0101	1364
0102	1255
0201	1524
0202	1290
0301	1488
0302	1256

Table-2: First Period and Eight (8) components of IKAD

Term	Under-standing of Materi- Material	Outcome	VS Varied Example	Task Exercise	Dis-cussion	Class-room Environment	Time Usage	Moti- vation
9901	2.61	2.5	1.63	1.58	2.73	2.68	2.69	2.84
9902	2.59	2.81	2.64	2.62	2.8	2.61	2.79	2.58
0001	2.68	2.94	2.75	2.66	2.91	2.72	2.89	2.71
0002	3.05	3.36	3.18	3.09	3.34	3.12	3.32	3.1
0101	3.05	3.36	3.15	3.12	3.36	3.12	3.31	3.12

Table-3: Second Period and Eight (8) components of IKAD

Term	Under-standing of Materi- Material	Outcome	VS Varied Example	Task Exercise	Dis-cussion	Class-room Environment	Time Usage	Moti- vation
0102	3.09	3.38	3.22	3.13	3.38	3.18	3.34	3.15
0201	3.03	3.34	3.15	3.16	3.38	3.12	3.31	3.11
0202	2.96	3.31	3.08	3.2	3.32	3.04	3.25	3.03
0301	2.96	3.32	3.07	3.19	3.32	3.05	3.23	3.07
0302	3.11	3.33	3.17	3.38	3.37	3.14	3.29	3.09

Table-4: The Average of IKAD Score for N-5 & N + 5

Periode	Under-standing of Materi- Material	Outcome	VS Varied Example	Task Exercise	Dis-cussion	Classroom Environment	Time Usage	Moti- vation
N-5	2.8	2.99	2.67	2.61	3.03	2.85	3	2.87
N+5	3	3.3	3.1	3.2	3.4	3.1	3.3	3.1

* Description:

N-5: The Average of IKADQ Score of 5 semesters before the implementation of MCL

N+5: The Average of IKADQ Score of 5 semesters after the implementation of MCL

In table 2 & 3, is the data of eighth component gathered before and after the implementation of MCL, the average IKAD score has been shown in that table.

From the figure 11, it can be shown in general, that there is an improvement for eight (8) components after the implementation of MCL in teaching and learning process at Bina Nusantara University. The most significant increasing is the varied example of learning material provided to engage in learning (the third component), and given exercise for students to practice is also give significant impact (the fourth component)

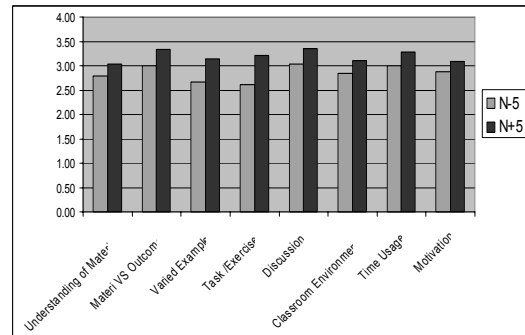


Fig. 11. The Graphics of the Average of IKAD Score before and after the implementation of MCL

VI. CONCLUSIONS

Bina Nusantara University, located in Jakarta Barat, Indonesia, having more than 23.000 students is recognized as IT based university, Since 2000 the university has developed ICT roles for teaching and learning activities by developing Multi Channel Learning (MCL) concept.

MCL is a learning model which combines student and lecturer's face to face activities in class using e-learning facilities and self- study done by students in the laboratory, library, experts' consultation, etc. Principally, MCL is a blended learning system.

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An Authoring Tool to Construct Adaptive Assessments

Héctor G. Barbosa León, Francisco J. García Peñalvo, Sergio Bravo
 University of Salamanca, Science Faculty, Plaza de los Caidos s/n, Salamanca, Spain 37008
 barbosah@usal.es, fgarcia@usal.es, ser@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 information and communication technologies in learning and teaching processes in order to increase the quality, efficiency, and dissemination of education. As long as those projects cover the needs of individuals in a particularly way, the success and transcendence of such developments could be incremented by performing adaptability to each user so the learning experience can be enhanced [1].

One accepted standard to develop these systems is the IMS [2] (Instructional Management Systems), a global learning consortium that develops and promotes the adoption

of open technical specifications for interoperable learning technologies that become the standards for delivering learning products worldwide.

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 [3], as this tends to isolate the assessment process from teaching and learning in general.

For us, the assessment activity after the student took the educative lesson could be seen as an element that contributes to the adaptation of the system to the learner needs or preferences as well. In addition, the assessment activity inside the e-learning process could be used to adapt the system by setting a new user knowledge level, evaluate, and setting new learning profiles, assign user grades and, in consequence, performing user content re-adaptation [4]. According to the Australian Flexible Learning Framework [5], assessment, especially when is included within a real learning task or exercises, could be an essential part of the learning experience,

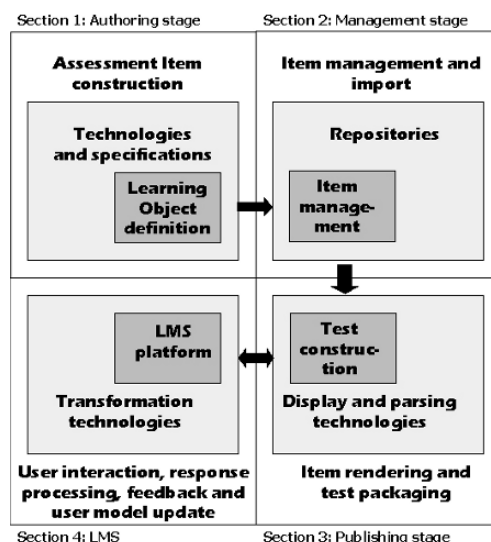


FIG. 1. MODEL TO CONSTRUCT ADAPTIVE ASSESSMENTS

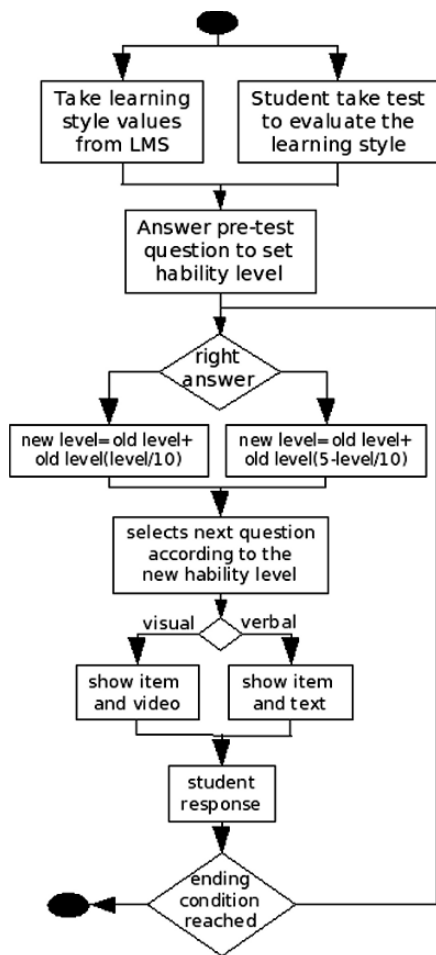


FIG. 2. ADAPTATION PROCESSES.

giving to the entire Web site the characteristic to adapt itself to the needs of the users.

The educative content is evolving from a static view to an adaptive one in which the content is adapted to the needs and/or preferences of the users. This content, developed in form of units of learning look to cover a specific learning objective including one or several learning objects and their related material.

Inside those objects we can find objects describing assessment activities to evaluate the knowledge of the students. The assessment activity inside a unit of learning could be seen as an element that closes and complete a circular activity, being an integral part of the learning process [6].

The rest of this article is organized as follow: in section II we show an overview of our model to construct adaptive assessments, in section III we show how we are planning to

construct the items and exams using open standards and specifications to ensure those objects could be used in several LMS. In section IV we describe briefly the main characteristics of the adaptation that we want to apply in the assessments. In section V we describe adaptation processes we want to incorporate in the learning objects. In VI a package organization is presented, finally in section VII we present our conclusions and future work.

II. MODEL OVERVIEW

We propose the construction of an integral assessment tool [7] to define educational exams that could perform an adaptation to the learning styles of the students. To do this, we show a model with four main sections (Fig. 1), some of them have three levels of conceptualizations with activity definitions from the abstract level (lower layers) to a more concrete level (upper layers).

I. Levels: from an abstract to a concrete view

In the first level (dark color), we identify the core elements (learning objects, management, test construction, and LMS - Learning Management Systems- interaction). In the second level (gray color), we describe the main sections, identifying four phases: authoring, repository management, visualization, and interaction with LMS. In the third level (white color), we categorize each activity into a subsystem (authoring, item management, publishing, and interaction with LMS).

II. Sections: from the definition to the use of learning objects in a Learning Management System

- Section one: Learning Object definition (ASI: Assessment, Section and Items). We define the basic files that could construct adaptive exams in the section 3. These files are the item definition itself (in IMS QTI [8] metadata) and several categorization files: (a) file containing accessibility instructions defined in IMS LD [9] metadata; (b) file containing adaptation rules defined in IMS LD metadata to construct a tree of nested questions; (c) file containing information for the description of the item in IMS LD and, (d) links to the multimedia files that will be used in the final presentation to the user.
- Section two: Item Management. We define this section with the aim to give to the developer a tool to organize, manage, and import ASI from other authoring tools. We propose a native XML (extensive Mark-up Language) database management system to manage the items.
- Section three: Test Construction. In this section the test constructor selects, visualize and construct the final exam from the individual items defined in the first section. The product of this section is package containing an exam or unit of learning in IMS CP [10] format. The manifest section contains the meta-data, organizations and resources meta-data for the item questions for each exam covering the three learning styles. In this way the section 3 of our model produces a package containing the final exam with meta-data referring to three packages, each one

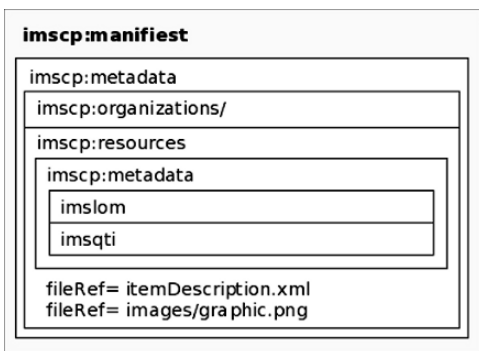


FIG. 3. FIRST LEVEL OF INTEGRATION FOR ITEMS.

defining an exam to each learning style. In this section the test constructor could visualize or make a rendering of the entire exam to verify the final presentation to the user.

- Section four: Test Delivery. In this phase, the candidate or student activates the test by accessing to it through an LMS, from which we get the learning style definition to make the adaptation. The LMS is in charge to send the responses given by the user that will be used by the package to select and perform the adaptation.

III. DEFINING ASSESSMENT ITEMS AND EXAMS USING IMS SPECIFICATIONS

I. Defining items using IMS QTI and IMS CP specifications

The IMS CP 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. In the case of a simple element, the package will contain (a) the manifest (XML file called `imsmanifest.xml`), (b) the item (QTI XML format file) and, (c) any auxiliary files required by the item (ref: `ims qti` integration guide).

II. Defining exams using IMS QTI, IMS LD and IMS CP specifications.

The IMS QTI and IMS LD specifications allow their integration to define a learning object to evaluate the knowledge acquired by the students when interact with a 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. But the IMS specifications could be 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, 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 `imsl:properties` to control the visibility and order of the elements and the `imsl: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).

IV. ADAPTIVE ASSESSMENTS

In this section, we want to focus in the adaptability characteristics to be included in the assessment. We split these characteristics in two groups: instructions for the accessibility and instructions for the adaptability.

I. Instructions for accessibility

These tags look to describe the instructions needed to perform adaptation to a specific learning style. The categorization for the learning styles is the one proposed in the IMS LD specification in which the visual, auditory and kinesthetic learning styles are included. These tags are included in the organizations and the resources section in a IMS CP package. We want to construct a package containing several questions whose final presentation could fulfill the requirements of one learning style in special.

II. Instructions for adaptability

These tags look to describe the instructions needed to construct a tree to perform adaptation in the sequence of the presentation of the question items to the final user. The tags will be defined inside the `organizations` section using `imss:sequencing` labels or in rules inside the methods section by using `imsl:labels`. This meta-data could adapt the presentation of the next question according to the response of the last question answered.

V. ADAPTATION PROCESSES

I. Adaptation in the final presentation to the user

The learning object could adapt their final presentation taking into account the needs or preferences of the users. For this, the learning object containing an adaptable exam includes content for each learning style through the use of a specific environment. The LMS access the appropriate environment that fit to the user learning style or preference, showing the multimedia material.

II. Adaptation in the complexity level

Another process of adaptation is the level of complexity of the questions that are presented to the student (Fig. 2). The questions are selected by their level of complexity, taking into account the response of the student to the last question

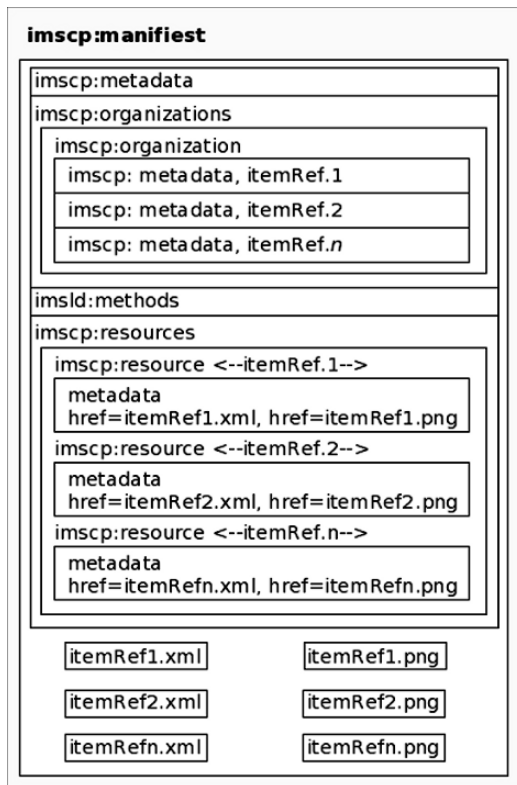


FIG. 4. SECOND LEVEL OF INTEGRATION FOR EXAMS.

answered. If he/she answer correctly then the next question is of the same or higher complexity, if not, then the next question is of a lower complexity. This is the traditional adaptation process used by some developments in this area [10], [11].

One of the main characteristics of the IMS LD specification is its potential to define adaptive characteristics covering the student preferences, prior knowledge and/or learning needs. To do this it is necessary to use this specification in the level B to define individual interactions because in this level we can use some elements like `<properties>` and `<conditions>`.

The learning style values could be set from values stored in the user model in the LMS and stored in property elements (`<loppers-property>`, `<globbers-property>`) to perform the adaptation. Finally, the `<on-completion>` element could be used to set the actions that will be done once certain action is performed. To perform adaptability to the learning style the LMS access the environment according to the need or selection of the user. From this, the questions set are presented to the student applying the adaptation algorithm proposed by [11].

Adaptation rule RUL1 is to perform adaptability according to the ability level and RUL2 is to adapt the presentation to the user learning style.

```
RUL1= IF <student>::(response,true)
      THEN
        newLevel = oldLevel+
        oldLevel (oldLevel/10)
      ELSE
        newLevel = oldLevel+
        oldLevel (5-oldLevel/10) .
```

```
RUL2= IF <student>::(LS_visual)
      THEN
        show item (newLevel,visual)
      ELSE
        show item (newLevel,verbal) .
```

VI. PACKAGE CONTENT AND ORGANIZATION

We propose three levels of integration, going from simple single items to complete exams with adaptability characteristics.

I. First level of integration

In this level, (Fig. 3) the *testConstructor* could integrate a single item in a package containing the item description and the auxiliary files or the reference to them. The aim for this package is to be exported to the LMS, to be part of complete exams compatible with the IMS QTI specification or to be referenced in learning objects using IMS LD labels.

II. Second level of integration

In this level (Fig. 4) the *testConstructor* could define a group of single items to construct a complete exam, for a specific learning style (or, in consequence, for the generic learning style), selecting the single items from the database that could evaluate a specific unit of learning. In this level we include IMS LD labels in the *imsld:methods* section to define sequencing rules to show the items according to their level of complexity.

III. Third level of integration

In this level (Fig. 5) the *testConstructor* could construct a package containing a complete exam for each learning style. This package could be seen as a learning object to supply an exam for a specific learning style, including adaptation rules to show the items according to the level of complexity.

VII. CONCLUSIONS

Online assessment is an important step inside the e-learning process because gives convenient feedback to all participants in the process, helping to improve the learning and teaching experience. Adaptability is another key factor in assessment.

Given the fact that assessment is an important element of the e-learning process and that this process looks to be interoperable, then we can think that the assessment tool could

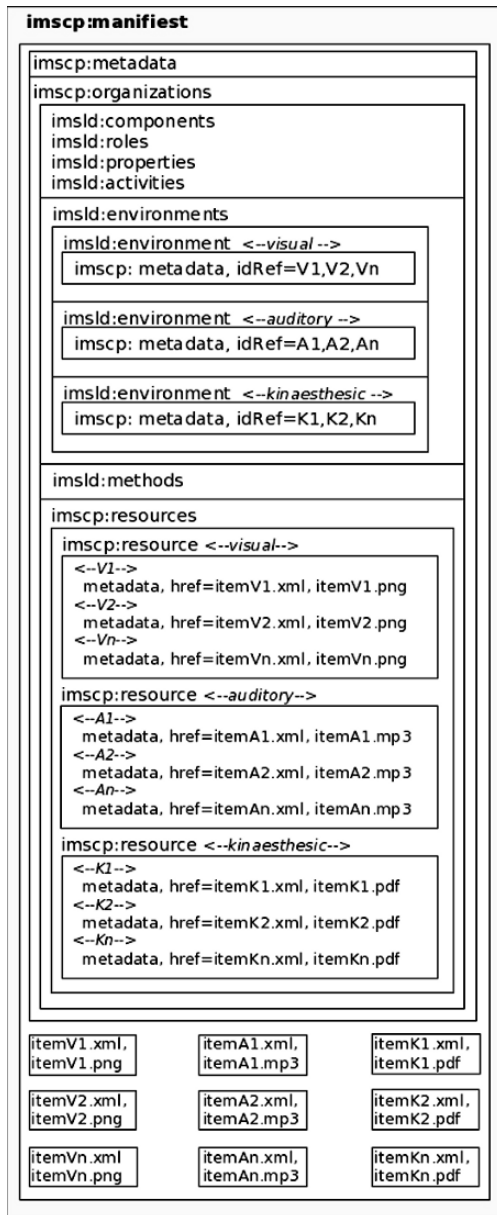


FIG. 5. THIRD LEVEL OF INTEGRATION FOR ADAPTIVE ASSESSMENTS

be used with different educative content administrators with different conceptualizations and ways to design and apply a test for their students.

Under this conceptualization, we want to create an Adaptive Assessment tool (AAT) that could take into account the specific characteristics of educational open systems. This

application will allow the teacher or instructional designer to integrate the test questions, with the supporting media and generate an output file in XML format, following the IMS specifications reviewed here.

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Delicious Learning Resources

Hend S. Al-Khalifa and Hugh C. Davis

Learning Technology Research Group, ECS, Southampton University, Southampton, UK
{hsak04r/hcd}@ecs.soton.ac.uk

Abstract – This paper presents a novel approach to semantic annotation of learning resources using a blend of folksonomy keywords and ontology-based semantic annotation. This approach attempts to match folksonomy terms (after normalization), from bookmarked resources saved in a bookmarking service such as del.icio.us, against terms in the ontology (which operates as a controlled vocabulary). The approach will provide an attribute-value relationship that is semantically rich and adds ‘intelligence’ to searches for learning resources in a specific subject domain.

I INTRODUCTION

Tagging, as a phenomena of assigned vocabulary, is considered one of the vital faces of the so-called Web 2.0™ era. Many web-based tagging systems such as del.icio.us¹, Flickr² and Odeo³ use tagging as a corner stone in their systems’ functionality. These systems operate by allowing users to assign a set of freely chosen textual labels (tags) to web pages, images, audio files or any other electronic resource to describe what a resource is about.

Tagging can also depict the consensus of taggers (people who assign tags to resources) and gives a web resource a flavor of reputation. Web services that foster the tagging mechanism are potential candidates for the application of data mining techniques on the tags that people have generated. This introduces possibilities for research from perspectives of computer science, social networks and information systems.

In principle, social bookmarking services, where people save their bookmarks for others to see, are considered one of the best-known web-based tagging systems. Since their inception in early 2003, with the del.icio.us service being among the first such services, many services have increased in popularity as means of social interaction [1].

Despite the popularity of such systems, there has been little work on extracting structured metadata from folksonomies. Automatic generation of semantic metadata (data that describes the meaning of a resource in a machine processable manner) is key research question, and folksonomies are a potentially rich source for such processing. The main question this paper is trying to articulate is: how can folksonomies be used to generate semantic metadata?

This paper will demonstrate a potential use of tags in producing semantically structured metadata for intelligent retrieval of web resources from an educational perspective. The feasibility of our proposed model will be verified by

applying it to a case study concerning the teaching of web design.

The paper will be structured as follows: Section 2 outlines the building blocks of the tool we have implemented to derive semantic metadata from folksonomies. Section 3, reports on a preliminary evaluation procedure carried out on the system output. Section 4, compares and contrast our system with other similar systems. Finally, the paper concludes with on going work and possible future research directions.

II SYSTEM ARCHITECTURE

We have implemented the FolksAnnotation Tool to convert folksonomies into semantic metadata. It consists of two components (as shown in Fig. 1): the Normalization pipeline, and the Semantic Annotation pipeline. Next, a detailed description of the two processes is discussed.

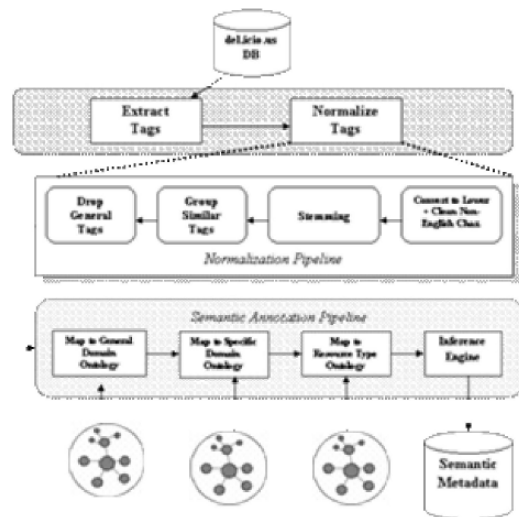


Fig. 1 System Architecture of the ‘FolksAnnotation’ Tool

A The Normalization pipeline

This process starts by fetching a bookmarked resource from the del.icio.us bookmarking service, so that the tag extraction process starts extracting viable information from the web page of the bookmarked web resource. This information includes: Web Resource Title, URL, Number of people who bookmarked the resource and the list of all tags assigned to the bookmarked resource.

¹ <http://del.icio.us>, social bookmarking service

² <http://www.flickr.com>, photo sharing service

³ <http://www.odeo.com>, audio (Podcast) sharing service

All tags assigned to a web resource in the del.icio.us service are extracted and then normalized using several techniques. First, tags are converted to lower case so that string manipulation (e.g. comparison) can be applied to them easily. Secondly, non-English characters are dropped; this step is to insure that only English tags are present when doing the semantic annotation process. Thirdly, tags are stemmed (e.g. converting plural to singular) using a modified version of Porter Stemmer⁴, then similar tags are grouped (e.g. inclusion of substrings). Finally, the general concept tags (e.g. ‘programming’, ‘web’, etc) in our domain of interest are eliminated. The process of normalization is done automatically and it is potentially useful to clean up the noise in peoples’ tags. Table I and Table II depict this process by giving an example of tags before and after normalization. Also, Fig. 2 shows a screen shot of part of the normalization program ‘in action’ on another web resource.

TABLE I
Tags used to annotate a sample web resource⁵ stored in the del.icio.us service (before normalization). The numbers refer to the frequency of occurrences

123 css	18 gui	7 howto	3 stats
56 design	14 html	5 tips	2 bargraph
47 graphs	12 webdev	5 usability	2 example
46 webdesign	10 reference	5 graphing	
28 graph	9 development	3 bar	
27 web	8 cool	3 coding	

TABLE II
Tags after applying the normalization process

123 css	10 reference	5 usability	2 example
80 graph	8 cool	5 bargraph	
18 gui	7 howto	3 code	
14 html	5 tip	3 stats	

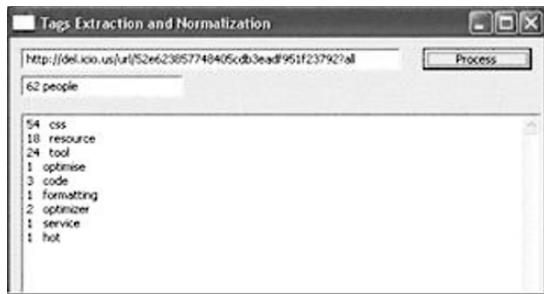


Fig. 2 Screenshot of the finished normalization process for a bookmarked web resource

The normalized list is then passed into the semantic annotation process, where each normalized folksonomy tag will be mapped to the different ontologies we are using, i.e. each tag is associated with a corresponding concept in one of three ontologies (explained in the next section). This

process will attach ontology terms as descriptions for a web resource.

B Semantic Annotation Pipeline

The semantic annotation process is the backbone process that generates semantic metadata using the three ontologies. The process attempts to match folksonomy terms (after normalizing them) from the bookmarked resource against terms in the ontology (which it will work as a controlled vocabulary) and only selects those terms that appear in the ontology.

The inference engine is responsible for associating pedagogical semantics to the annotated web resource. In our system we define two pedagogical semantic terms. ‘Instructional level’ can be basic, intermediate or advanced and refers to where the concept fits within the domain being studied. ‘Difficulty’ can be easy, medium or hard, and describes how conceptually difficult this resource will be to understand within the domain and instructional level concerned.

These two pedagogical values are generated from a set of inference rules so long as enough information is available in the basic semantic descriptors. For example, given a web resource within the domain of ‘CSS’ tagged with a folksonomy value of ‘font’ the inference engine would trigger the rule that states “if a web resource has a tag value of ‘font’ then its difficulty will be ‘easy’ and its instructional level will be ‘basic’”.

After finishing the annotation process, each item of the generated semantic metadata is saved in a database (e.g. a triple store) for later query by a dedicated interface.

III THE SYSTEM ONTOLOGIES

In the previous section we talked about the use of three ontologies in our system. This section will highlight the importance of having ontologies in our system and frame the three ontologies we have built to fulfill the system purpose.

The main goal for building ontologies in e-Learning systems is to represent the semantics of the learning resource; such semantics are stored in repositories, so that they can be reused, shared and queried by users (e.g. teachers and students).

Moreover, ontologies form the base for generating semantic metadata, and in our proposed system, they are used to add more fine grained semantics to web resources.

A Ontological Modeling of the three Ontologies

The three ontologies in our system were chosen based on observed patterns in peoples’ tags in the del.icio.us bookmarking service for our domain of interest (for this case study our domain of interest is the teaching of ‘CSS’ within ‘web design’). In other words, the three ontologies we have modeled are the domain of ‘web design’, the subject of ‘CSS’ and the learning resources ‘types’. For that reason, the three ontologies were designed with a web design and development course in mind, and they were

⁴ <http://www.tartarus.org/martin/PorterStemmer/>

⁵ <http://apples-to-oranges.com/blog/examples/cssgraphs.html>, Date Accessed May 12, 2006 at 10:00 PM GMT

built using Protégé⁶ ontology editor and saved in OWL DL format.

B Web Design Domain Ontology

The domain ontology represents an abstract level of the domain of ‘web design’ and the relation of the concepts in that domain. The rationale for using a domain ontology is to place the CSS subject ontology in the context of its domain.

C CSS Subject Ontology

Fig. 3 shows the CSS ontology. The ontology gives a fine grained listing of the concepts used in the subject of CSS. We derived this ontology from assorted websites that classify the subject of CSS.



Fig. 3 is-a diagram showing the hierarchical relation between the main concepts in the subject of CSS

D Resource Type Ontology

Type Ontology models resource types that go beyond the scope of the common-set provided by IEEE-LOM. The rationale behind using a different vocabulary set is that different learning resources can come in a variety of forms. To give an example, suppose a learning resource was of type ‘editor’, a software tool used to create or modify files of a particular type. A possible use of the resource will be to use it as an additional resource in the context of a programming course. This type of resource and others have not been mentioned in the IEEE-LOM resource type set; so, new vocabulary needs to be modeled to represent the new resources emerging in people’s vocabulary.

E The Semantic Metadata

Learning resources are usually described using standards such as Dublin Core and IEEE LOM with their RDF bindings. The semantic metadata used in this system builds on these standards and adds more fine grained semantics to

web resources. In other words, parts of the generated semantic metadata elements were derived from the IEEE-LOM standard. These elements include the web resource title, description, URL, difficulty and keywords.

The rest of the generated semantic metadata elements were derived from our ontologies. These include fine grained elements that are dedicated for the subject of ‘CSS’.

IV PRELIMINARY EVALUATION

To evaluate the performance of the generated semantic metadata, we have embarked an evaluation procedure adopted from [2], where they compared keywords against semantic topic search. However, in our system we have compared the performance of folksonomy search against semantic topic search to see which search results in more relevant records.

We produced an evaluation tool to allow us to search CSS topics (e.g. BoxModel, Layout, Navigation, Positioning and Typography.) in two ways. For the first search we queried the folksonomy for the topic and in the second search we conducted a semantic search on the CSS ontology for the same topic.

In some cases the number of resources returned by the semantic search is higher as the semantic search benefits from the relationship between topics in the CSS ontology, in this case the ‘related_to’ relationship which links between related concepts. For instance, when someone searches for the topic ‘positioning’, all resources that have as their subject the word ‘positioning’ plus all related resources will be retrieved. Table III shows the result obtained when searching for the (positioning and navigation) topics in the CSS ontology.

TABLE III
The Relevance Result between Folksonomy Search and Subject Search Using CSS Ontology

CSS Topic	Positioning	
	Folksonomy Search	Subject Search
Number of records found	3	4
Number of records relevant to topic	3/4	4/4
CSS Topic	Navigation	
	Folksonomy Search	Subject Search
Number of records found	1	2
Number of records relevant to topic	1/2	2/2

As it appears from the results the semantic search outperforms folksonomy search in our sample test, this is because folksonomy search, even if the folksonomy keywords were produced by humans, is analogous to keyword search and therefore limited [9].

⁶ <http://protege.stanford.edu/>

V RELATED WORK

Automatic metadata generation is a well-known research area in the field of library science. Our presented work extends this research area by exploiting other features from multiple research domains including: the Semantic Web, eLearning and Web technologies.

Basically, automatic metadata generation techniques can be categorized into two types: Techniques to generate Standard Metadata, and Techniques to generate Semantic Metadata. Our paper will talk about the two genres and how do they relate to our current work.

A Standard Metadata Techniques

Most metadata assignment techniques follow one of two approaches: extraction or classification [4]. In the extraction approach, metadata is extracted from documents using techniques such as natural language processing. This approach is appropriate for uncontrolled metadata fields such as title, description and creator. On the other hand, the classification approach relies on controlled vocabulary to assign metadata to documents.

There are many metadata extraction and generation tools used in an educational context, among them is the DC-dot program that extracts Dublin core from the author's META tags in an HTML document. Another application is the automatic metadata generation framework (AMG) developed by Erik Duval and his team [3]. Their prototype framework operates by extracting metadata from the content in two learning management systems namely: SIDWeb and Toledo-Blackboard. Despite the fact that the extracted metadata is compliant to IEEE-LOM it only provides values to a limited number of elements in the LOM. However, for those fields where metadata can be automatically generated, the accuracy of the data is assured, when compared to a manual assignment.

The previously mentioned systems generate LOM metadata, primarily for human consumption. The scope of their research is different from our main research theme and so our system produces its metadata in a format suitable for machine processing by semantic web tools.

B Semantic Metadata Techniques

In a developing field such as the Semantic Web, it is impossible to complete a comprehensive survey of the new tools and new versions of existing tools that are used to generate semantic metadata, due to the rapid progress in this area. However, most of these tools are created to generate general purpose semantic metadata, without taking into consideration the requirements of the educational field (e.g. [5]; [6]).

Luckily, some examples from the semantic domain do exist that adhere to the requirements of educational domain. The most recent example is an ongoing project carried out in the laboratories of Advanced Research in Intelligent educational Systems (ARIES), Canada [8]. This project is replacing the standard metadata (i.e. IEEE-LOM) with more flexible ecological approach based on semantics. The approach sees metadata as the process of reasoning over observed interactions of users with a learning object for a particular purpose.

Another example is the TANGRAM system [7]. TANGRAM is a learning web application for the domain of Intelligent Information Systems (IIS) where users (students and teachers) can upload, describe, search or compose a new learning object using components in the system repository. The system provides a solution for automatic metadata generation of learning objects (LO) components. Thus, each generated semantic metadata attached to a LO allows the TANGRAM system to assemble these objects into new LOs personalized to the users' goals, preferences and learning style.

Despite the similarity between the purpose and outcome of the TANGRAM system and our system, our system does not rely on any algorithms to generate or extract metadata from web resources (that are equivalent to LO). Moreover, our system uses a freely accessible web service (i.e. del.icio.us) for generating semantic metadata, while the TANGRAM system operates from within a learning management system. Finally, our system adds an extra layer of semantics to existing human generated metadata (i.e. folksonomies) which opens the doors for a wide range of intelligent applications.

VI DISCUSSION

From the previous overview it is apparent that our work differs from prior research in automatic metadata generation in number of ways. First, our system relies on keywords generated by people to create the semantic metadata, while this approach is novel; the authors have not encountered any research dealing with such an approach. Secondly, our system has not used any kind of algorithms to extract keywords from web resources; thus, it gets use of people's tags to generate new values to the elements of the semantic metadata. Finally, our system generates semantic metadata rather than standard metadata.

VII CONCLUSION AND ON GOING WORK

Our aim in this research was to show that semantic metadata can be potentially generated using folksonomies guided by domain ontologies. And to some extent we tried to show that part of our claim is valid by reporting on the results of the preliminary evaluation.

However, despite the preliminary evaluation results, which showed that semantic search of folksonomies is more powerful than searching by folksonomies alone, further rigorous evaluation procedures are planned. This will include the measurement of the validity, quality and performance of the generated semantic metadata.

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The effect of the CABLE approach on the levels of mental engagement of students in computer programming

Dr Ioana Tuugalei Chan Mow

National University of Samoa

Dr Wing Au

University of South Australia

Dr Gregory Yates

University of South Australia

Abstract: This paper reports on the findings of the third of a series of trials (Project 3) which evaluated the impact of CABLE, a cognitive apprenticeship based learning environment on the teaching of computer programming at the National University of Samoa. The results of the first two trials (Project 1 and Project 2) had shown that students exposed to CABLE evidenced increased scores on a post-test relative to those taught in the traditional (non-CABLE) mode of instruction. The aim of Project 3 was to investigate the effect of CABLE on the levels of mental engagement of students. The results of Project 3 indicated significant differences, in the levels of mental engagement, in students taught programming skills within CABLE classes, when compared to students taught programming skills within non-CABLE classes.

1 INTRODUCTION

Teaching computer programming skills within the university context has proven to be a difficult and challenging task. The cognitive load placed upon students is heavy [1], and it is unclear if traditional instructional practices are optimal within this area. Traditionally, student attrition levels have been high, and ways to address such problems need to be considered [2]. This research is concerned with ways to improve university course materials and instructional provisions, specifically within the context of teaching advanced programming skills to undergraduate students at the National University of Samoa.

Over a three-year period, an instructional program was developed, and referred to as CABLE (Cognitive Apprenticeship Based Learning Environment) [2]. This approach was informed through considerations of recent cognitive learning theories such as collaborative learning, information processing, and cognitive apprenticeship. The CABLE model was evaluated in a series of field trials (Projects 1, 2, and 3). In Project 1 and Project 2, the CABLE approach was evaluated by contrasting it with the traditional approach to university instruction [3]. The main aim of Project 3 was to evaluate the effectiveness of the learning environment, based on self-reporting by students on their levels of engagement.

Students in both the CABLE and traditional groups were given the same set of instructional materials in their JAVA

training, and participated in similar lectures and practicum classes. The main differences between the two approaches were: (a) the use of structured and individualised feedback in CABLE by means of an email help desk; (b) the provision of a rich metacognitive experience through articulation and the use of “think alouds”, feedback from the lecturers, careful scaffolding in terms of questions posed throughout the study materials; and (c) structured collaboration in class projects and activities.

Project 3 was the last of the CABLE field trials. The specific aim of Project 3 was to investigate the effect of CABLE on the levels of students’ mental engagement as indexed on self report measures. From this aim, the following hypothesis was formulated:

Hypothesis: Students taught programming in CABLE will exhibit higher levels of mental engagement when compared to students taught programming using traditional methods of course instruction.

Project 3 was undertaken to investigate if the CABLE approach could be associated with other motivational outcomes. Thus concern arose in that it was hoped that students would respond to the CABLE procedures with positive appraisals. But efforts to establish levels of reported affect over and above traditional treatments had been unsuccessful. The CABLE teaching teams had reported that the students appeared well-motivated and appreciative of the instructional provisions. Hence, Project 3 was planned in the effort to further explore the question of whether or not the CABLE procedures, could be associated with beneficial motivational outcomes, other than achievement measures.

The decision was made to operationalise the motivational factor, however, in terms of self-reported engagement. The assumption was that students would be willing to rate their level of engagement within a course, along a line scale (“not engaged”, to “engaged”). This procedure could be carried out in such a manner as to avoid some of the sensitivity associated with the term “motivation”. That is, we did not want students to rate themselves as “not motivated” if we are taking such a measure early within the course duration. The goal was to

obtain ratings of engagement at three time points during the semester. It was possible to tap engagement at these points within the 12 week semester at 6-weeks, 9-weeks and at 12 -weeks.

For the present study, mental engagement is defined as “*the intensity and emotional quality of children’s involvement in initiating and carrying out learning activities...*” [4]. The term “learning task engagement” is used in the present study to refer to students’ cognitive investment, active participation, and emotional engagement with specific learning tasks [5]. Self-reporting measures will be used to rate levels of engagement. Student engagement will be assessed on the level of students’ investment in, and their emotional reactions to, the learning tasks (e.g., high levels of interest or positive attitudes towards in the learning tasks). Engagement levels have been found to relate positively to students’ confidence and self-efficacy for achieving specific learning outcomes [6] (Schunk & Zimmerman, 1994). In short, it is possible to suggest that engagement stands as a valid and meaningful proxy variable representing a means of tapping into the motivational nature of the students’ learning experience.

2. PARTICIPANTS

Participants for Project 3 were 57 students from four Java Computer programming classes, CSB381, CSB286, CSB181 and CSB281. The first two classes were taught using the CABLE procedures and the other two were taught via the traditional university mode of instruction. Thirty one students (15 females, 16 males) participated in the CABLE classes and 26 students (9 females, 17 males) participated in the non-CABLE classes. The participants were students in the age range of 17 to 21, and were enrolled in either second or third year Java programming classes at the National University of Samoa. These participants can be regarded as being drawn from the same population but enrolled in different electives. It should also be noted that none of the participants was enrolled in more than one such class. The sizes of the classes were all in the range of 14 to 18 students, and thus some level of individual attention was naturally possible within all four courses. All four courses were taught by two experienced male lecturers aged 35 and 38, knowledgeable within their areas and with more than 5 years of teaching experience in programming. There was some variability in the number of responses to the evaluation instruments, across the three evaluation periods and this was due to absences on the day of the evaluation, or participants failing to respond to some of the questions.

3. INSTRUMENTATION

The questionnaire consisted of 9 items, 7 using the graduated line principle and 2 stems requiring written responses. The graduated line principle is also referred to as the bipolar anchor method as students were asked to respond along a 7-point scale between two clearly opposing anchor points. The first 7 items evaluated student perceptions on the following aspects as (a) how stimulating their learning experience was (b) how demanding the work load, (c) the amount of learning, (d) the

amount of reading, (e) how engaging the approach was (f) how rewarding, and (g) the volume of work. Following the ratings, the last two questions were open-ended. The first such question asked of problems encountered by students, and the second question asked for student recommendations on course improvement.

4. PROCEDURES

In Project 3, two Java programming classes were taught using the CABLE approach. Another two Java programming classes were taught using the traditional university approach (non-CABLE). The CABLE classes were taught in accordance with procedures as developed within Project 1 and Project 2. The main aim of Project 3 was to evaluate whether the CABLE environment facilitated high levels of engagement in students. Levels of engagement were rated by participants using 7-point rating scales. To gauge their levels of engagement, questionnaires were administered to students in the CABLE and non-CABLE environment at three different times during the semester, in week 6, week 9 and week 12. Week 6, week 9 and week 12 correspond to the variables *Time1*, *Time2* and *Time3* respectively in the analysis. To provide a contrast, the levels of engagement of the CABLE classes were compared to those of the non-CABLE classes. The questionnaires were administered by a research assistant who had been recruited for this purpose. Before the administration of the questionnaire, it was explained to the participants, that the purpose of the questionnaire, was to rate how much work and engagement was required by different courses. Test scores from two achievement tests, administered at the beginning and at the end of the CABLE course were collected to enable engagement levels to be correlated with actual achievement data. Achievement data were not available for the non-CABLE classes.

Another distinguishing factor of the CABLE approach in Project 3 was the introduction of scaffolding software which generates UML diagrams and subsequent program code. As indicated in earlier projects, UML modelling is an aspect of object oriented programming which students found problematic and hence the development of scaffolding software to generate UML diagrams. UML stands for Unified Modelling Language and uses a graphical notation to showcase the structure and substructure of a system using objects, operations, attributes and associations. The effectiveness of this scaffolding software for UML modelling was evaluated by student interviews.

5. ANALYSES AND RESULTS

The analyses of the data are reported in two sections. The first section reports on the analyses of individual items. The second section reports on the analyses of aggregated data.

A. Analyses on the Seven Motivational Ratings

Treatment of gender and class. The gender factor was looked at firstly, and entered into both ANOVAs and regression analyses. In no case did gender emerge as a main effect, and no interaction terms or regression coefficients achieved significance. It was concluded that gender did not impact upon any of the motivational variables measured on the questionnaire. Another set of preliminary analyses indicated that the two traditional classes provided ratings that did not differ significantly. However, when the parallel analyses were applied to the two CABLE classes, some differences did achieve a level of significance on *Time1* and *Time2*, but not *Time3*. Apparently one of the CABLE classes received slightly higher ratings on *Time1* and *Time2*. The pattern was not a consistent one across indices. This aspect is further described in the data aggregate section, and the overall effect is then depicted in Figure 4.

Boring vs Stimulating. A repeated measures ANOVA was conducted on this factor using Treatment (CABLE vs Non-CABLE classes) and Time (*Time1*, *Time2*, *Time3*) as independent variables. A significant effect for treatment was found, $F(1, 48) = 31.9, p < .001$. Treatment did not interact significantly with Time. Thus, students clearly rated the CABLE classes as more stimulating than the other classes across all time periods. Means representing scores out of seven for each of the dimensions are depicted in Figure 2.

Non-demanding vs demanding. A repeated measures ANOVA indicated a significant effect for treatment, $F(1, 48) = 6.9, p = .01$. The treatment by Time interaction term was at a 10% significance level, $F(2, 96) = 2.4, p = .09$. This effect was followed up with separate one-way ANOVAs conducted on each of the three time periods. It was found that a significant effect for treatment was evident at *Time1* and *Time2*, but not at *Time3*. This effect is depicted in Figure 1.

Amount of learning. A repeated measures ANOVA indicated a significant effect for treatment, $F(1, 47) = 15.8, p < .001$. Interaction effects were not significant.

Amount of reading. A repeated measures ANOVA indicated no significant effects.

Engagement. A repeated measures ANOVA indicated a significant effect for treatment, $F(1, 47) = 6.5, p = .01$. The interaction term was not significant.

Rewarding. A repeated measures ANOVA indicated a significant effect for treatment, $F(1, 48) = 13.2, p = .001$. The interaction term was not significant.

Much work. A repeated measures ANOVA indicated no significant effects on these ratings.

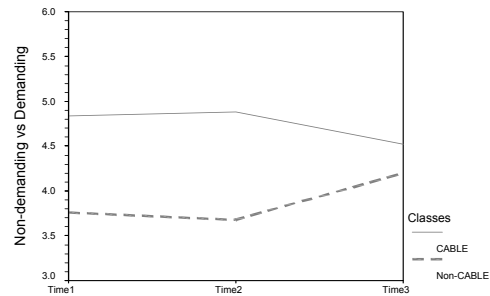


Fig.1. Student ratings (means) on course demandingness

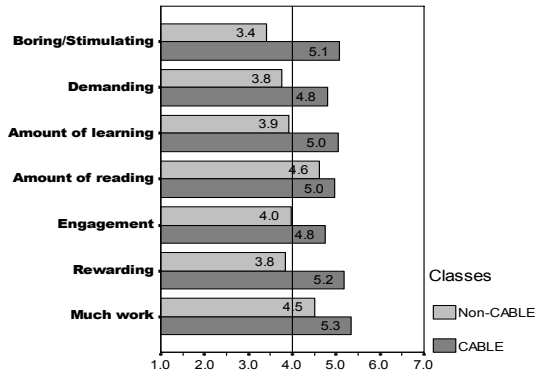
A repeated measures ANOVA on Item 7, on perceived volume of work, with time as the within subject factor, indicated a 10% significant effect ($F(1, 47) = 3.2, p = .08$). The time effect was not significant, nor was the time by treatment interaction.

B. Aggregated Data

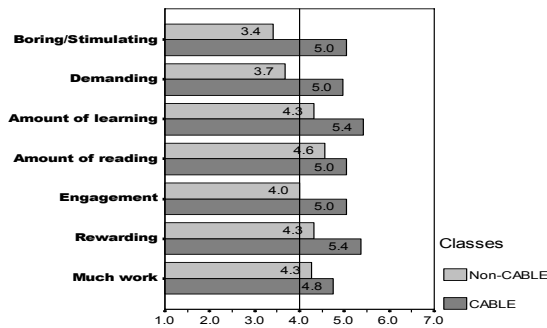
Separate factor analyses on the 7 items (Questions 1 – 7) using a Principal Components procedure indicated that for each of *Time1*, *Time2* and *Time3*, a single factor resolution was possible for the first 6 items (Questions 1 – 6). That is, these 6 items loaded strongly upon one factor, but the final item did not load markedly. Three measures of engagement level (*EAL1*, *EAL2*, *EAL3*) to correspond to each of the three evaluation times, (*Time1*, *Time2*, *Time3*) were thus derived from aggregating scores from the first 6 questions of the engagement questionnaire.

SPSS Reliability analyses were then used to check on scale properties, when all 6 items are summed to one scale, for each of the three aggregates. For *Time1*, the internal reliability coefficient alpha was found to be 0.83, with all items contributing strongly. The factor Engagement Aggregate Level 1 (*EAL1*), was created for *Time1*, with mean of 26.8 and SD of 6.9. In addition, acceptable curve properties were evident, with kurtosis of .29 and skewness of -1.08. For *Time2*, the internal reliability coefficient alpha was found to be 0.83, with all items contributing significantly. The factor Engagement Aggregate Level 2 (*EAL2*), was created for *Time2*, with mean of 27.8 and SD of 6.8. In addition, acceptable curve properties were evident, with kurtosis of -.58 and skewness of .39. For *Time3*, the internal reliability coefficient alpha was found to be 0.75, with all items contributing strongly. The factor Engagement Aggregate Level 3 (*EAL3*), was created for *Time3*, with mean of 28.6 and SD of 5.7. Acceptable curve properties were evident, with kurtosis of -.22 and skewness of .47.

Time1



Time2



Time3

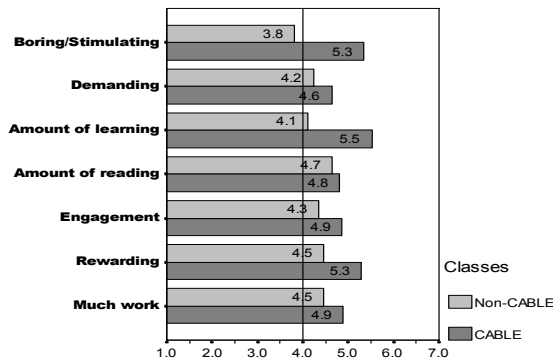


Fig.2. Student ratings (means) across courses at times T1, T2 and T3
The 3 aggregate variables, *EAL1*, *EAL2*, and *EAL3* were used for making comparisons across treatments and across

evaluation times. It can be noted that the three Engagement Aggregate Level (*EAL*) scores were constructed following on from factor analysis. That is, all 6 items were found to be tapping into a psychological trait, whereas the 7th item (much work) did not fit this trait. Examination of the six items led us to regard them as representing the overall trait of “course engagement”, interpreted in a manner consistent with the initial expectation that reported engagement stands for how motivating a course is, during its tenure.

C. Effects of Gender

A set of ANOVAs using gender as the independent variable indicated that no significant main effects were attributable to gender upon *EAL1*, *EAL2*, *EAL3*. It was decided that, in general, gender effects would not be included within further analyses.

D. Engagement Aggregates

Overall levels of mental engagement of the participants were evaluated by analyses of the aggregate variables (*EAL1*, *EAL2*, and *EAL3*). One-way ANOVA procedures on *EAL1*, *EAL2* and *EAL3*, all indicated a highly significant difference between the two treatment groups at each of these times. Effects are for *Time1*, $F(1, 52) = 15.1, p = .01$, *Time2* ($F(1, 50) = 16.6, p = .01$), and *Time3* ($F(1, 50) = 19.3, p = .01$) respectively. These effects are shown in Figure 3 and Table 1.

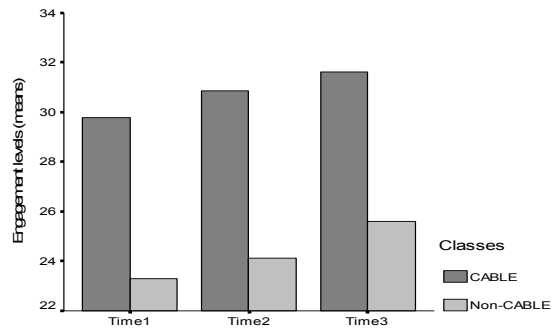


Fig.3. Student engagement levels at *Time1*, *Time2* and *Time3*

A repeated measures ANOVA on engagement levels (*EAL1*, *EAL2*, *EAL3*) with time as the within subject factor indicated a highly significant effect due to treatment group, ($F(1, 52) = 32.4, p < .001$). However the effect for time was not significant, nor was the time by treatment interaction term, i.e., the apparent increase from *Time1* to *Time3* seen in Figure 4 does not represent a significant trend. Effect sizes (Cohens *d*) for the 3 aggregates were 1.06 for *EAL1*, 1.16 for *EAL2* and 1.22 for *EAL3*.

TABLE 1
MEAN ENGAGEMENT LEVELS AT TIME1, TIME2 AND TIME3

Evaluation time	Overall Mean n= 53	CABLE Mean n = 27	Non-CABLE Mean n = 26	F (1, 52)	p
Engagement aggregate Time1 (EAL1)	26.8	29.8	23.3	15.1	<.001
Engagement aggregate Time2 (EAL2)	27.8	30.9	24.1	16.6	<.001
Engagement aggregate Time3 (EAL3)	28.6	31.6	25.6	19.3	<.001

As indicated earlier, it had been found that on several indices at *Time1* and *Time2*, one of the CABLE classes had received slightly higher ratings than the other. Because the pattern was not a reliable one, however, it is appropriate to report the finding on the basis of engagement aggregate data. The two CABLE classes differed marginally on *Time1* and *Time2* but not on *Time3*. This relationship is shown in Figure 4.

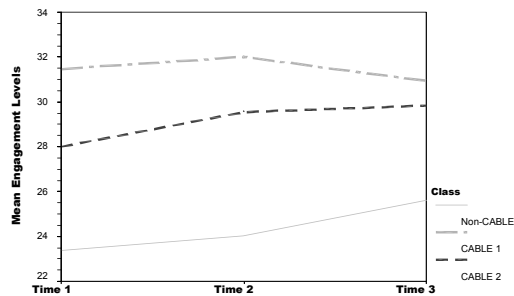


Fig.4. Engagement levels in CABLE and Non-CABLE courses

E. Q11: Problems Encountered in Using this Learning Environment?

The following were student responses detailing problems encountered during the study.

Time1

In the CABLE group, ten students reported having no problems. The main problems encountered were: (a) difficulty in writing Java code, (b) insufficient time for completing exercises and reading, (c) heavy workload, and (d) distraction from non-class members.

In the non-CABLE group, two students reported having no problems. The main problems reported were: (a) difficulty in writing Java code, (b) insufficient support from the lecturer, (c)

computer breakdown, (d) distraction from non-class members, and (e) insufficient time for exercises.

Time2

In the CABLE group, 8 out of 20 reported having no problems. The most common complaints were: (a) the need for more explanations, (b) more practicals and exercises, (c) distraction from other students, and (d) technical problems.

In the non-CABLE group, two reported having no problems. The main problems experienced by students were: (a) insufficient number of exercises, (b) insufficient help from staff, (c) insufficient time for reading, and (d) difficulty of gaining access to computers.

Time3

In the CABLE group, 5 reported encountering no problems. The main difficulties experienced were: (a) writing Java code, (b) insufficient time for exercises, (c) need for more explanations, (d) distractions from other class members, and (e) technical problems.

In the non-CABLE group, 3 reported having no problems. The main difficulties experienced were the same as reported in previous evaluations such as: (a) insufficient number of exercises, (b) insufficient help from staff, (c) insufficient time for reading, and (d) difficulty of gaining access to computers.

F. Q12: Recommendations for Improving the Learning Environment

The following were student responses detailing recommendations for the improvement of their learning environment.

Time1

For both the CABLE and non-CABLE groups, common recommendations were: (a) more examples, (b) more practicals, and (c) more explanations. In addition, the non-CABLE group recommended better lecturer preparation.

Time2

The recommendations made by participants of the CABLE group included: (a) more practicals and exercises, (b) more explanations and (c) better network access. The non-CABLE group made similar recommendations but in addition, recommended better facilities and better lecturing.

Time3

For the third evaluation (*Time3*), the recommendations were the same as for those proposed in previous evaluation times for both the CABLE and non-CABLE groups.

G. Student Interviews on Effectiveness of UML Software

All of the students interviewed found the software to be useful but not very user friendly. The main problems encountered were the difficulty in defining the UML diagram. These responses point to the need for more development and modification of the UML modelling software. Work on improving the UML software is still ongoing with the hope of using the software for UML modelling in the introductory level Java courses.

H. Intercorrelations

Correlation analyses indicated that although the two test scores correlated significantly, the motivational scores failed to correlate significantly with achievement data. A matrix of these correlations appear in Table 2, based on only 23 individuals. A regression analysis was attempted to see if motivational scores would predict test 2 scores after controlling for test1 data. Although trends were apparent, the number of students was insufficient to allow these trends to become significant.

TABLE 2
INTERCORRELATION MATRIX FOR PROJECT 3

	Test2	EAL1	EAL2	EAL3
Test1	.54**	.31	.27	.31
Test2		-.05	.18	.05
EAL1			.81**	.31
EAL2				.11

Note: n = 23, ** $p < 0.01$ level (one-tailed test)

The aim of Project 3 was to investigate the effect of CABLE on levels of students' mental engagement as indexed on self reporting measures. The results for Project 3 are considered in relation to the specific hypothesis tendered for the present project, that students taught programming skills in CABLE will exhibit higher levels of mental engagement when compared to students taught using traditional methods of course instruction.

The data gave support to this hypothesis that CABLE classes appeared to be more strongly motivating than non-CABLE classes. When examining for the differences on each of the 7 ratings, it was apparent that, the most significant differences were obtained in the case of (a) the boring vs stimulating dimension, with an F of 31, (b) amount of learning, with an F of 15, and (c) sense of reward, with an F of 13. These represent substantial overall effects. The other two significant effects were for demandingness (F of 7), and engagement (F of 6). However, by *Time3*, both CABLE and non-CABLE classes were seen as

equally demanding. We have no specific explanation as to why the impact of CABLE appeared more strongly on some dimensions, but it is reassuring to note that CABLE classes did seem to be rated simultaneously as stimulating and a good deal of work, as well as rewarding. Such data augur well for future applications.

The data on course sense of demand are of some curiosity, in that it seemed that within the non-CABLE courses, levels of demandingness increased during the semester, whereas they were relatively high (4.8 out of 7) for the CABLE courses throughout. Perhaps one of the benefits of CABLE lies in students being aware of how much work is involved at an earlier point in time than for alternative approaches.

One-way ANOVA procedures on the aggregate variables (*EAL1*, *EAL2*, and *EAL3*), and one-way ANOVA procedures on individual questionnaire items for engagement levels for *Time1*, *Time2* and *Time3*, all indicated a highly significant difference between the two treatment groups at each of these times, with the CABLE group showing higher levels of mental engagement. Hence, analyses of all the test measures consistently showed the CABLE group as exhibiting higher levels of mental engagement than the traditional (non-CABLE) group.

There is an apparent discrepancy in that the effect of CABLE was not significant in the case of the seventh item (not much work vs lots of work). Although the trend was for CABLE students to rate their courses as higher, on this aspect, (see Figure 3), the differences failed to achieve significance. Perhaps this item is not a viable index of engagement since to rate a course as "lots of work" may have negative connotations. Factor analysis suggested this item did not tap into the intended dimension of engagement.

Hence, to conclude, we make the claim that the results of Project 3 support the hypothesis, that students taught programming in CABLE exhibited higher levels of mental engagement when compared to students taught using traditional means.

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Fuzzy TOPSIS Method for Academic Member Selection in Engineering Faculty

İrfan Ertuğrul

Department of Business Administration, Pamukkale University, Denizli, Turkey
iertugrul@pamukkale.edu.tr

Nilsen Karakaşoğlu

Department of Business Administration, Pamukkale University, Denizli, Turkey
nkarakasoglu@pamukkale.edu.tr

Abstract- This paper presents fuzzy TOPSIS (technique for order preference by similarity to ideal solution) method for academic member selection. In academic member selection problem the ratings of various alternatives versus various subjective criteria and the weights of all criteria are assessed in linguistic variables represented by fuzzy numbers. Fuzzy numbers try to resolve the ambiguity of concepts that are associated with human being's judgments. To determine the order of the alternatives, closeness coefficient is defined by calculating the distances to the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS). Universities can select the appropriate academic member by using fuzzy TOPSIS method. By this way the quality of education will be increased in universities.

I. INTRODUCTION

Decision making problem is the process of finding the best option from all of the alternatives [1]. Academic member selection is a multi-criteria decision making problem. The decision is to select the best candidate for the faculty.

Selection of new academic member requires a great deal of consideration from the selection committee. The conventional process of selecting a new academic member starts with announcements given to a newspaper and internet. Candidates apply for the position. And selection committee tries to select the most appropriate candidate for the university [2]. To select the most appropriate candidate, selection committee sets the selection criteria. In this study selection criteria are teaching skills, past experiences, publications and researches, references and education. The evaluation data of academic member suitability for various subjective criteria and the weights of the criteria are usually expressed in linguistic terms. Thus, a fuzzy TOPSIS method is proposed in this paper, where the ratings of various alternatives and the weights of all criteria are assessed in linguistic terms represented by fuzzy numbers.

TOPSIS method was firstly proposed by Hwang and Yoon [3]. According to this technique, the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution [4]. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal

solution maximizes the cost criteria and minimizes the benefit criteria [5].

In this paper, the extended TOPSIS method is considered which was originally proposed by Chen [6]. In classical TOPSIS, the ratings and the weights of the criteria are known precisely. However, under many conditions, crisp data are inadequate to model real life situations since human judgments are often vague and decision makers cannot estimate their preferences with an exact numerical value [7]. To give interval judgments than fixed value judgments is more confident for decision makers. So, triangular fuzzy numbers are used to express the linguistic ratings of decision makers. In fuzzy TOPSIS the decision makers use the linguistic variables to assess the importance of the criteria and to evaluate the each alternative with respect to each criterion. These linguistic variables are converted into triangular fuzzy numbers and fuzzy decision matrix is formed. Then normalized fuzzy decision matrix and weighted normalized fuzzy decision matrix are formed. After FPIS and FNIS are defined, the closeness coefficient of each alternative is calculated. According to these values, decision maker can determine the order of the alternatives and can choose the best one.

The rest of the paper is organized as follows: in the following section, first, basic concepts such as fuzzy sets, fuzzy numbers are tried to be defined; then, the fuzzy TOPSIS method is introduced. In Section IV, a numerical example of academic member selection problem is illustrated. Lastly, the Section V concludes.

II. BASIC CONCEPTS

A. Fuzzy Sets

“Not very clear”, “probably so”, “very likely”, these terms of expression can be heard very often in daily life and their commonality is that they are more or less tainted with uncertainty. With different daily decision making problems of diverse intensity, the results can be misleading if the fuzziness of human decision making is not taken into account [8]. In order to deal with vagueness of human thought, Zadeh [9] first introduced the fuzzy set theory. A fuzzy set is an extension of a crisp set. Crisp sets only allow full membership or no membership at all, whereas fuzzy sets allow partial

membership. In other words, an element may partially belong to a fuzzy set.

The classical set theory is built on the fundamental concept of set of which is either a member or not a member. A sharp, crisp and unambiguous distinction exists between a member and non-member for any well-defined set of entities in this theory and there is a very precise and clear boundary to indicate if an entity belongs to the set. But many real-world applications cannot be described and handled by classical set theory [10].

Zadeh, proposed to use values ranging from 0 to 1 for showing the membership of the objects in a fuzzy set. Complete non-membership is represented by 0, and complete membership as 1. Values between 0 and 1 represent intermediate degrees of membership [11].

Fuzzy sets and fuzzy logic are powerful mathematical tools for modeling: uncertain systems in industry, nature and humanity; and facilitators for common-sense reasoning in decision making in the absence of complete and precise information. Their role is significant when applied to complex phenomena not easily described by traditional mathematical methods, especially when the goal is to find a good approximate solution [12].

B. Fuzzy Numbers

A fuzzy number is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1 [13]. It is possible to use different fuzzy numbers according to the situation. Generally in practice triangular and trapezoidal fuzzy numbers are used [14].

C. Triangular Fuzzy Numbers (TFNs)

In applications it is often convenient to work with TFNs because of their computational simplicity, and they are useful in promoting representation and information processing in a fuzzy environment. In this study TFNs in the fuzzy TOPSIS are adopted.

A tilde ‘~’ will be placed above a symbol if the symbol represents a fuzzy set. Triangular fuzzy numbers are expressed as (n_1, n_2, n_3) . The parameters n_1, n_2 , and n_3 respectively, indicate the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. A triangular fuzzy number (TFN), \tilde{n} is shown in Fig. 1. [13]

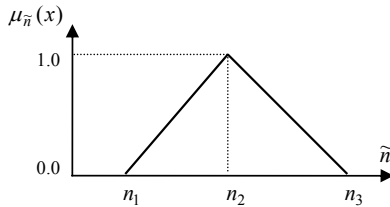


Fig. 1. Triangular Fuzzy Number, \tilde{n}

Triangular fuzzy numbers are a special class of fuzzy numbers, defined by three real numbers, expressed as (n_1, n_2, n_3) and their membership functions are described as:

$$\mu(x/\tilde{M}) = \begin{cases} 0, & x < n_1, \\ (x-n_1)/(n_2-n_1), & n_1 \leq x \leq n_2, \\ (n_3-x)/(n_3-n_2), & n_2 \leq x \leq n_3, \\ 0, & x > n_3 \end{cases} \quad (1)$$

D. Algebraic Operations on TFNs

There are various operations on TFNs. But here, three important operations used in this study are illustrated. If we define, two positive TFNs \tilde{m} and \tilde{n} by the triplets $\tilde{m} = (m_1, m_2, m_3)$ and $\tilde{n} = (n_1, n_2, n_3)$ then,

$$\begin{aligned} \tilde{m} \oplus \tilde{n} &= (m_1, m_2, m_3) \oplus (n_1, n_2, n_3) \\ &= (m_1 + n_1, m_2 + n_2, m_3 + n_3) \end{aligned} \quad (2)$$

$$\begin{aligned} \tilde{m} \otimes \tilde{n} &= (m_1, m_2, m_3) \otimes (n_1, n_2, n_3) \\ &= (m_1 n_1, m_2 n_2, m_3 n_3) \end{aligned} \quad (3)$$

$$\begin{aligned} \tilde{m} \otimes k &= (m_1 k, m_2 k, m_3 k) \end{aligned} \quad (4)$$

(k is a positive real number)

The distance between two triangular fuzzy numbers can be calculated by using vertex method as [6]:

$$d_v(\tilde{m}, \tilde{n}) = \sqrt{\frac{1}{3} [(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \quad (5)$$

The vertex method is an effective and simple method to calculate the distance between two triangular fuzzy numbers. According to the vertex method, two triangular fuzzy numbers \tilde{m} and \tilde{n} are the same numbers if $d_v(\tilde{m}, \tilde{n}) = 0$. Let \tilde{m} , \tilde{n} and \tilde{p} are three triangular fuzzy numbers. Fuzzy number \tilde{n} is closer to fuzzy number \tilde{m} than the other fuzzy number \tilde{p} if $d_v(\tilde{m}, \tilde{n}) < d_v(\tilde{m}, \tilde{p})$ [15].

III. FUZZY TOPSIS METHOD

Fuzzy TOPSIS method is explained in this section. In this paper the importance weights of various criteria and ratings of qualitative criteria are considered as linguistic variables. Because linguistic assessments are appropriate for the subjective judgment of decision-makers. We use triangular fuzzy numbers to capture the vagueness of the linguistic assessments. The decision makers use the linguistic variables shown in Fig. 2 and Fig. 3 to evaluate the importance of the criteria and the ratings of alternatives with respect to criteria [15].

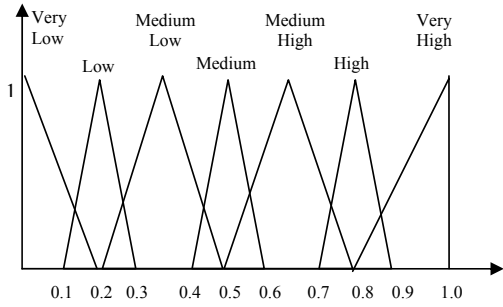


Fig. 2. Linguistic Variables for Importance Weight of Each Criterion

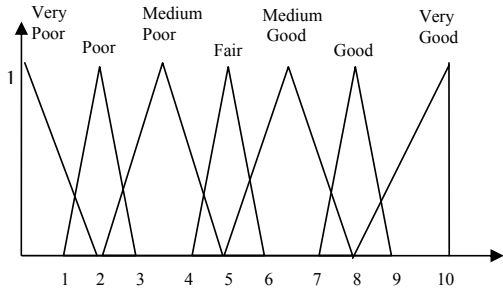


Fig. 3. Linguistic Variables for Ratings

The fuzzy TOPSIS method can be described by the help of following sets [15]:

- a set of K decision-makers called $E = \{D_1, D_2, \dots, D_K\}$;
- a set of m possible alternatives called; $A = \{A_1, A_2, \dots, A_m\}$;
- a set of n criteria, $C = \{C_1, C_2, \dots, C_n\}$, with which alternative performances are measured;
- a set of performance ratings of $A_i = \{i = 1, 2, \dots, m\}$ with respect to criteria $C_j = \{j = 1, 2, \dots, n\}$ called $X = \{x_{ij}, i = 1, 2, \dots, m, j = 1, 2, \dots, n\}$

In a decision committee that has K decision makers, fuzzy rating of each decision maker $D_k = (k = 1, 2, \dots, K)$ can be represented as triangular fuzzy number $\tilde{R}_k = (k = 1, 2, \dots, K)$ with membership function $\mu_{\tilde{R}_k}(x)$.

Let the fuzzy ratings of all decision-makers be triangular fuzzy numbers $\tilde{R}_k = (a_k, b_k, c_k)$, $k = 1, 2, \dots, K$. Then the aggregated fuzzy rating can be defined as

$$\tilde{R} = (a, b, c), \quad k = 1, 2, \dots, K \quad (6)$$

where;

$$a = \min_k \{a_k\}, \quad b = \frac{1}{K} \sum_{k=1}^K b_k, \quad c = \max_k \{c_k\}$$

Let the fuzzy rating and importance weight of the k th decision maker be $\tilde{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ and $\tilde{w}_{ijk} = (w_{jk1}, w_{jk2}, w_{jk3})$, $i = 1, 2, \dots, m$, $j = 1, 2, \dots, n$ respectively. Then the aggregated fuzzy ratings (\tilde{x}_{ij}) of alternatives with respect to each criterion can be calculated as ($\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$) (7)

$$a_{ij} = \min_k \{a_{ijk}\}, \quad b_{ij} = \frac{1}{K} \sum_{k=1}^K b_{ijk}, \quad c_{ij} = \max_k \{c_{ijk}\}$$

The aggregated fuzzy weights (\tilde{w}_{ij}) of each criterion can be calculated as:

$$(\tilde{w}_{ij} = (w_{j1}, w_{j2}, w_{j3})), \quad (8)$$

where

$$w_{j1} = \min_k \{w_{jk1}\}, \quad w_{j2} = \frac{1}{K} \sum_{k=1}^K w_{jk2}, \quad w_{j3} = \max_k \{w_{jk3}\}$$

Then academic member selection problem can be expressed in matrix format as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix},$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_n]$$

where $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$; $i = 1, 2, \dots, m$, $j = 1, 2, \dots, n$ can be approximated by positive triangular fuzzy numbers. [15]

To avoid the complicated normalization formula used in classical TOPSIS, the linear scale transformation can be used to transform the various criteria scales into a comparable scale. Therefore, it is possible to obtain the normalized fuzzy decision matrix denoted by \tilde{R} [7]:

$$\tilde{R} = [\tilde{r}_{ij}]_{m \times n} \quad (9)$$

where B and C are the set of benefit criteria and cost criteria respectively:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right), \quad j \in B;$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right), \quad j \in C;$$

$$c_j^* = \max_i c_{ij}, \quad \text{if } j \in B;$$

$$a_j^- = \min_i a_{ij}, \quad \text{if } j \in C.$$

The normalization method mentioned above is designed to preserve the property in which the elements $r_{ij}, \forall i, j$ are normalized triangular fuzzy numbers.

Considering the different importance of each criterion, the weighted normalized fuzzy-decision matrix is formed as:

$$\tilde{V} = [\tilde{v}_{ij}]_{m \times n} \quad i = 1, 2, \dots, m \quad j = 1, 2, \dots, n \quad (10)$$

where, $\tilde{v}_{ij} = \tilde{r}_{ij}(\cdot)\tilde{w}_j$.

According to the weighted normalized fuzzy-decision matrix, normalized positive triangular fuzzy numbers can also approximate the elements $\tilde{v}_{ij}, \forall i, j$. Then, the fuzzy positive ideal solution (FPIS, A^*) and fuzzy negative ideal solution (FNIS, A^-) can be defined as [15]:

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*), \quad (11)$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-), \quad (12)$$

where

$$\tilde{v}_j^* = \max_i \{v_{ij3}\} \quad \text{and} \quad \tilde{v}_j^- = \min_i \{v_{ij1}\}$$

$$i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n.$$

The distance of each alternative from A^* and A^- can be calculated as:

$$d_i^* = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1, 2, \dots, m \quad (13)$$

$$d_i^- = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1, 2, \dots, m \quad (14)$$

where $d_v(\cdot, \cdot)$ is the distance measurement between two fuzzy numbers.

A closeness coefficient (CC_i) is defined to determine the order of all possible alternatives. The closeness coefficient represents the distances to the fuzzy positive ideal solution (A^*) and fuzzy negative ideal solution (A^-) simultaneously. The closeness coefficient of each alternative is calculated as:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \quad i = 1, 2, \dots, m \quad (15)$$

It is clear that $CC_i = 1$ if $A_i = A^*$ and $CC_i = 0$ if $A_i = A^-$. The order of all alternatives can be determined according to the descending order of CC_i .

The algorithm of the fuzzy TOPSIS method can be summarized as follows [15]:

1. A committee of decision-makers is formed and then evaluation criteria are determined.
2. Appropriate linguistic variables for the importance weight of the criteria and linguistic ratings for alternatives are determined by decision-makers.
3. The weights of criteria are aggregated to get the total fuzzy weight w_i of the criterion C_j and decision maker's ratings are gathered to get the aggregated fuzzy rating x_{ij} of alternative A_i under criterion C_j .
4. Fuzzy-decision matrix and normalized fuzzy decision matrix are formed.

5. Weighted normalized fuzzy decision matrix is formed.
6. Fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are determined.
7. The distance of each alternative from FPIS and FNIS are calculated.
8. The closeness coefficient of each alternative is calculated.
9. By comparing the closeness coefficient, order of all alternatives can be determined.

IV. NUMERICAL EXAMPLE

Suppose that a university want to choose academic member to engineering faculty and three candidates apply for the position. A committee of three decision makers $D_1, D_2,$ and D_3 has been formed for selecting the most appropriate candidate for the university. Five criteria are determined for selection process:

- C_1 Teaching Skills
- C_2 Past Experiences
- C_3 Publications and Researches
- C_4 References
- C_5 Education

The hierarchical structure of the problem is shown in Fig. 4 The fuzzy TOPSIS method is applied to solve this problem. Three decision makers use the linguistic variables shown in Fig. 2 and Fig. 3 for assessing the importance of the criteria.

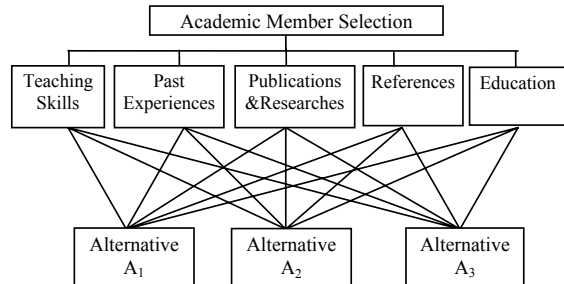


Fig. 4. The hierarchical structure of decision problem

Decision makers use the linguistic variables in Fig. 2 to evaluate the importance of criteria. The importance weights of the criteria determined by these three decision makers are shown in Table I.

TABLE I.

Importance Weight Of Criteria from Three Decision-Makers

Criteria	Decision-Makers		
	D ₁	D ₂	D ₃
C ₁	MH	H	VH
C ₂	MH	H	M
C ₃	VH	VH	H
C ₄	MH	MH	MH
C ₅	H	VH	H

Three decision makers use the linguistic variables shown in Fig. 3 to evaluate the ratings of candidates with respect to each criterion. The ratings of three candidates under five criteria are shown in Table II.

TABLE II.

Ratings of the Three Candidates by Decision-Makers Under Five Criteria

Criteria	Alternatives	Decision-Makers		
		D ₁	D ₂	D ₃
C ₁	A ₁	G	G	MG
	A ₂	MG	F	MP
	A ₃	VG	G	G
C ₂	A ₁	MP	F	F
	A ₂	G	F	G
	A ₃	G	G	G
C ₃	A ₁	G	MG	G
	A ₂	F	F	MP
	A ₃	MG	G	G
C ₄	A ₁	F	MG	MG
	A ₂	G	VG	G
	A ₃	F	G	MG
C ₅	A ₁	G	G	G
	A ₂	MG	G	MG
	A ₃	G	VG	G

Then linguistic variables shown in Table I and II are converted into triangular fuzzy numbers to form fuzzy decision matrix as shown in Table III.

TABLE III.

Fuzzy Decision Matrix and Fuzzy Weights Of Three Candidates

	A ₁	A ₂	A ₃	Weight
C ₁	(5, 7.5, 9)	(2, 5, 8)	(7, 8.7, 10)	(0.5, 0.82, 1)
C ₂	(2, 4.5, 6)	(4, 7, 9)	(7, 8, 9)	(0.4, 0.65, 0.9)
C ₃	(5, 7.5, 9)	(2, 4.5, 6)	(5, 7.5, 9)	(0.7, 0.93, 1)
C ₄	(4, 6, 8)	(7, 8.7, 10)	(4, 6.5, 9)	(0.5, 0.65, 0.8)
C ₅	(7, 8, 9)	(5, 7, 9)	(7, 8.7, 10)	(0.7, 0.87, 1)

The normalized fuzzy decision matrix is formed as in Table IV. Then weighted normalized fuzzy decision matrix is formed as in Table V.

TABLE IV.

Normalized Fuzzy Decision Matrix

	A ₁	A ₂	A ₃
C ₁	(0.5, 0.75, 0.9)	(0.2, 0.5, 0.8)	(0.7, 0.87, 1)
C ₂	(0.2, 0.45, 0.6)	(0.4, 0.7, 0.9)	(0.7, 0.8, 0.9)
C ₃	(0.5, 0.75, 0.9)	(0.2, 0.45, 0.6)	(0.5, 0.75, 0.9)
C ₄	(0.4, 0.6, 0.8)	(0.7, 0.87, 1)	(0.4, 0.65, 0.9)
C ₅	(0.7, 0.8, 0.9)	(0.5, 0.7, 0.9)	(0.7, 0.87, 1)

TABLE V.

Weighted Normalized Fuzzy Decision Matrix

	A ₁	A ₂	A ₃
C ₁	(0.25, 0.62, 0.9)	(0.1, 0.41, 0.8)	(0.35, 0.71, 1)
C ₂	(0.08, 0.29, 0.54)	(0.16, 0.46, 0.81)	(0.28, 0.52, 0.81)
C ₃	(0.35, 0.7, 0.9)	(0.14, 0.42, 0.6)	(0.35, 0.7, 0.9)
C ₄	(0.2, 0.39, 0.64)	(0.35, 0.57, 0.8)	(0.2, 0.42, 0.72)
C ₅	(0.49, 0.7, 0.9)	(0.35, 0.61, 0.9)	(0.49, 0.76, 1)

After forming weighted normalized fuzzy decision matrix FPIS and FNIS are determined as;

$$A^* = [(1, 1, 1), (0.81, 0.81, 0.81), (0.9, 0.9, 0.9), (0.8, 0.8, 0.8), (1, 1, 1)]$$

$$A^- = [(0.1, 0.1, 0.1), (0.08, 0.08, 0.08), (0.14, 0.14, 0.14), (0.2, 0.2, 0.2), 0.35, 0.35, 0.35]$$

Then the distance of each alternative from FPIS and FNIS with respect to each criterion are calculated as;

$$d(A_1, A^*) = \sqrt{\frac{1}{3}[(1-0.25)^2 + (1-0.62)^2 + (1-0.9)^2]} = 0.49$$

$$d(A_1, A^-) = \sqrt{\frac{1}{3}[(0.1-0.25)^2 + (0.1-0.62)^2 + (0.1-0.9)^2]} = 0.56$$

Here only the calculation of the distance of the first alternative to FPIS and FNIS for the first criterion is shown, as the calculations are similar in all steps. The results of all alternatives' distances from FPIS and FNIS are shown in Table VI and VII.

TABLE VI.

Distances Between $A_i (i=1,2,3)$ and A^* With Respect to Each Criterion

	$d(A_1, A^*)$	$d(A_2, A^*)$	$d(A_3, A^*)$
C ₁	0.49	0.63	0.41
C ₂	0.54	0.43	0.35
C ₃	0.34	0.55	0.34
C ₄	0.43	0.29	0.41
C ₅	0.35	0.44	0.33

TABLE VII.

Distances Between $A_i (i=1,2,3)$ and A^- With Respect to Each Criterion

	$d(A_1, A^-)$	$d(A_2, A^-)$	$d(A_3, A^-)$
C ₁	0.56	0.44	0.65
C ₂	0.29	0.48	0.51
C ₃	0.56	0.31	0.56
C ₄	0.28	0.41	0.33
C ₅	0.38	0.35	0.45

d_i^* and d_i^- of three alternatives are shown in Table VIII.

Then closeness coefficient of three alternatives are calculated as

$$CC_1 = \frac{2.07}{2.15 + 2.07} = 0.49 \quad CC_2 = \frac{1.99}{2.34 + 1.99} = 0.46$$

$$CC_3 = \frac{1.84}{2.48 + 1.84} = 0.58$$

TABLE VIII.

Computations of d_i^* , d_i^- and CC_i

	A_1	A_2	A_3
d_i^*	2,15	2,34	1,84
d_i^-	2,07	1,99	2,48
$d_i^*+d_i^-$	4,21	4,34	4,32
CC_i	0,49	0,46	0,58

According to the closeness coefficient of three alternatives, the order of these alternatives is $A_3 > A_1 > A_2$. Engineering faculty of the university will choose the Alternative 3 as its closeness coefficient has the highest value. In other words, the third alternative is closer to the FPIS and farther from the FNIS.

V. CONCLUSION

Academic member selection is an important process for the universities as this decision affects the quality of education and the success of the university. Decision committee faces up to the uncertainty and vagueness in the decision-making process. Fuzzy theory can be used in many decision making areas like that. By using fuzzy TOPSIS, uncertainty and vagueness from subjective perception and the experiences of decision maker can be effectively represented and reached to a more effective decision.

In this study academic member selection via fuzzy TOPSIS method has been proposed. The decision criteria are teaching skills, past experience, publications and researches, references and education. These criteria were evaluated to determine the order of candidates for selecting the most appropriate one for the faculty. By the help of the fuzzy approach, the ambiguities involved in the data could be effectively represented and processed to make a more effective decision. As a result of this study the third candidate is determined as the best alternative which has the highest closeness coefficient.

The distance between two fuzzy triangular numbers is calculated with vertex method in this study. But other methods like Minkowski, Hamming, Euclidean or Chebyshev distance can be used in calculating the distance between two fuzzy numbers. And the results can be compared in further applications.

In future studies other multi-criteria methods like fuzzy AHP that have been recently proposed in a fuzzy environment can be used in academic member selection. And also the proposed method can be applied to other multi-criteria decision problems of the university.

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Guidelines of Proposal Writing and Project Descriptions

I. D. Mikus – J. Varsányi

Europrofessional EC, Budapest – Széchenyi István University, Győr, Hungary

euro@kszi.hu – vjudit@agistra.hu

Abstract – This article deals with the relevant success factors of proposal writing and project description, based on long range experiences in the area of Leonardo and other large projects of skills development in Eastern-European regions. Authors emphasize the role of establishment and professionalism in the proposal writing and project success. The article offers a framework and practical guidelines for trainers of proposal writing as well.¹

I. INTRODUCTION

The purpose of recent paper is to formulate the key principles of proposal writing and several guidelines, in order to help with a successful project management.

The guidelines are based on our experiences gained in Leonardo da Vinci and other EU-projects during the last decade. We contributed to the first Leonardo programme in Hungary, targeting the establishment of proposal writing trainings for directors of vocational institutes. We elaborated a large set of training materials, moderated the trainings as professional teamworks and, elaborated the methodology of the evaluation of efficiency of training courses [7, 8, 19, 20].

During the last years, our participation in numerous project management programmes helped with collecting new experiences in the proposal writing and project planning tasks, with special respect to the contents and quality requirements and, consequently, to the process of evaluation.

II. SUCCESS FACTORS OF PROJECTS

The larger projects usually require more comprehensive establishment. Guidelines and scenarii are not enough for a successful implementation. To establish a good project plan, a manual is necessary, containing detailed project plan, methodology, competence schemes, strict deadlines, personal tasks and responsibilities. The manual requires uniform task descriptions. This is necessary to guarantee standardized professional contents of each task and to facilitate a rapid and high level compilation of details into a feasibility study [15].

The more complex projects contain a large set of project modules. The project plan should contain the summary and details of each module, showing the cross impacts of each on other. In order to standardize the modules, uniform requirements of contents and structure are to be determined. Participants should fulfil their tasks according to these requirements.

The feasibility is a relevant question of project success. Promoters require to elaborate a well established feasibility study therefore.

In this study, needs and opportunities should be compared to each other, creating a feasibility balance based on them. All of anticipated constraints, barriers, disturbing or delaying factors should be taken into consideration, pre-calculating their possible impacts on the realization [1, 2, 23].

The financial budget is partly an important pre-condition of a successful project impacting on the feasibility and, on the other hand, it influences the payoff of the investment projects as well. Fig. 1 indicates several financial criteria of the project feasibility – partly as actual indicators and, partly as long range indicators of financial position [18].

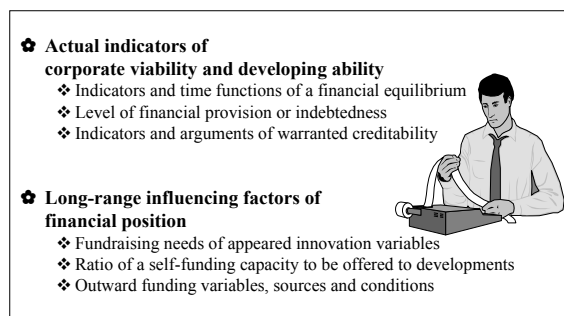


Fig. 1. Financial criteria of project feasibility [18].

The benefits of project highly depend on the ratio of its business and social character. The business benefits should be forecasted and calculated. The social benefits, however, usually are of secondary and long-term character. They may rather be considered as accounted. In both case, the beneficiary stakeholders, industrial or geographical areas or social layers should be denominated and, the impacts of project on their existence should be forecasted [6, 10, 23].

Finally, the sustainability, dissemination and long term advantages of a project should be presented in a project plan. That means, the project plan should present how to maintain the advantages realized by the project, how to extend its positive impacts to further areas or social layers and, which factors should be built-up in order to maintain the benefits for a long term period [20, 21].

III. STRUCTURE OF PROJECT PLANS

Project plans and their annexes – first of all the feasibility studies – should be made in a logical, consistent and transpar-

¹ Figures are illustrated by PrintMaster clipart graphics, Mindscape, USA.

ent structure, in appropriate page formats. In a usual case, the A4 format is to be preferred. In the case of a printed, edited issue, customary is a B5 format as well.

The logical structure means an introduction referring to the project purpose, an executive summary with the essential factors of project, the detailed discussion and a chapter with the key conclusions should be written. These chapters should well be built-up to each other, they should show a logical chain, with acceptable page ratios. This means, the introduction and conclusions may be as long as 2-3 pages, the executive summary of 3-5 pages. The extent of detailed discussion depends on the volume and complexity of project – between 15–30 pages. All of the further informations should be given as annexes [22].

The description of project modules starts with a mission statement and key purposes. The most important details of modules are:

- Description of technical parameters.
- Organizational requirements of the project.
- Resource needs.
- Financial budget
- Expected benefits.

The resource needs should be broken down into informational background, technical, information technology (IT) needs, intellectual capital and human resource needs. The IT needs include various hardware and software requirements. The human relation (HR) needs include the manpower capacity, the purchased intellectual goods and the volume and structure of necessary skills.

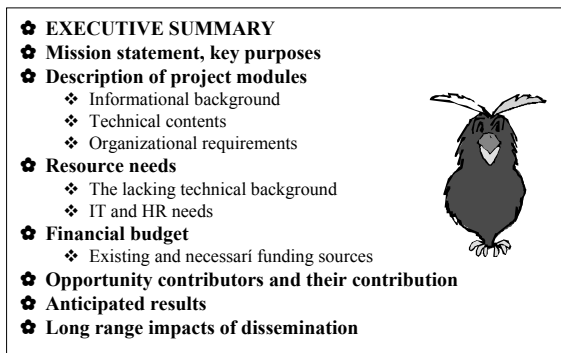


Fig. 2. The structure of a project plan.

The financial budget starts with the estimation of necessary financial cover of resource needs calculated. Thereafter, it should be broken down into the existing financial power and, into ratios of additional funding sources – contributions from business partners or institutional stakeholders, opportunity supports from tendering promoters, contributions from capital investors (e.g. as proprietary or venture capital) and bank loans.

It should be taken into consideration that the financial needs may highly depend on the turnaround time of project implementation. The too short deadlines may lead to high additional

capital need. The too far deadlines, in contrary, may result in opportunity costs because of the delay of benefits. The scarce resources may cause delay of realization which lead to further opportunity costs. Consequently, the realistic planning of turnaround time is essential for gaining financial success of project.

The feasibility studies should contain all of necessary details of realization of the project, the abstract of which should build an important part of project plans. These studies may extend sometimes to 50-100 pages if the pre-conditions and tasks are too complicated. The structure of feasibility studies is similar to those of project plans, with similar chapter contents and ratios.

IV. USE OF TEMPLATES OR SAMPLES

A. General considerations

Targeting uniform contents, structure and quality of project plans, professional project engineers usually generate project templates. The templates serve to guarantee not only a standard for general contents, key parts, focuses and structure but, furthermore, samples of page formats, tables, questionnaires, word processing and text editing styles and further imagery prescriptions or samples, as it is summarized in Fig. 3.

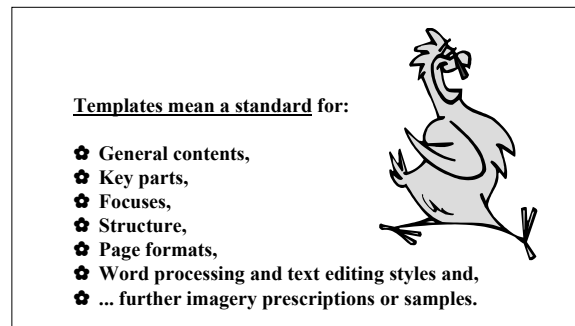


Fig. 3. The role of templates.

In order to guarantee a uniform quality of project plans, participants should accept and follow the templates.

The Microsoft Word, the general text processing software has very broad capabilities to edit a professional text. The problem is that these capabilities are not wide spread in the range of users. The documents usually are edited by a low level of professionalism as if they would be written by a type-writer. Persons e.g. who are non-professional in using the Word, type empty rows (simple ENTERs) instead of leads between the lines. Moreover, sometimes occurs that ENTERs are typed on the ends of lines.

The professional Word-users work with text editing styles. The Microsoft Word processing software is very rich on these professional tools. Styles are at disposal e.g. for different characters, titles, text paragraphs. Further styles may be used for constructing an attractive list of content. By other styles, tables may be constructed or, figures or charts may be inserted in an appropriate imagery and size. This only requires a short time of learning by testing all of menu offers and, all of styles sup-

plied. The broadest opportunity to use the Word is, to create user styles according to the promoter’s requirements.

The list of contents may be made and automatically updated by the Word processing software itself. The only problem is that the Word is sensible to the automatically numbered title styles. Therefore, a manual numbering of chapters, without using numbering commands in title styles is required in order to avoid this problem.

Imagery prescriptions may be milder or more rigorous, depending on the character and contents of a proposal or a project plan required. Promoters frequently offer text editing samples in order to enable participants to formulate studies of similar structure, extent and transparency. Such samples should contain e.g. examples of title levels, a list of contents automatically generated from the titles, several sample inward parts, e.g. tables, figures, charts with their titles, footnotes and, literature references if required.

B. Cover page and list of contents

An attractive image of cover page plays a brand building role in the consulting process. As an example, the cover page of one of our EU-project studies is to be seen in Fig. 4.



Fig. 4. Cover page of an EU study.

The cover page of a professional study should show an attractive imagery with logos of authors and/or stakeholders. The title should, however, NOT have any other styles than a Normal one – in order to avoid that the automatic list of contents contain the title of cover page as well [22].

Name of authors, of their company or institution and, furthermore, the date and place should be written on the cover page. Attractiveness and the similarity of cover pages of different studies about the same project may be anticipated.

A list of contents with page numbers is initial in order to be able to follow the structure of project plans and feasibility studies. This list should be made automatically by the Word text processing software. This process requires only an inserting command at its final place – usually behind the cover page. Originally, the Word gives specific „list of contents“ styles to each title level. These may, however, be not always appropriate to the style of study. Therefore, a sample is preferred to be used, formulating the styles of each title level, guaranteeing a transparent and attractive imagery.

C. Tables and inserted charts

Tables of the studies should be constructed to a size between the margins, with characteristic title and head styles. The column width and row height should be chosen according to the contents. The inward text style should guarantee the readability. The uniform image of each table within the same study is important as well. An example is to be seen below.

TABLE I
ASPECTS OF TABLES PRESENTED

ASPECTS	PROPOSED SOLUTIONS
Table name	To be short and characteristic to the topic concerned
Table head	Bold or emphasized otherwise; Marked as “Title row” to be appeared on the next page as well
Table contents	Key criteria and indicators only
Table width	Between margins
Column width	According to the contents, without hyphenation
Data source	Referred to by its bibliographic data

Charts made by Excel or by other application should be inserted into an empty paragraph. In this case, it will get exactly an in-margin size. Figures from another application should be similarly inserted.

Figures should NEVER be drawn by the Word – mainly because these figures may not be edited later if another size or format is required. Word is not able to catch and re-size the whole figure and, sometimes, the original figure slips away or its fragments pass over the margin if the document will be printed from another computer.

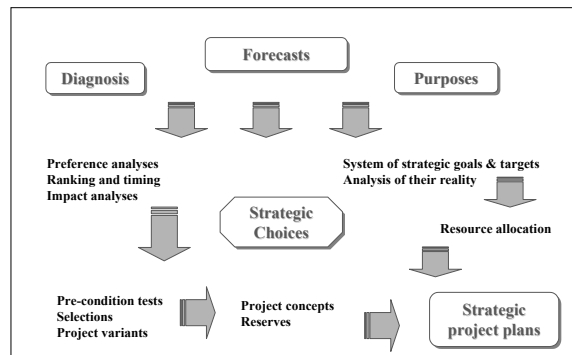


Fig. 5. A pattern of strategic way of thinking [15].

The PowerPoint is a proper application for this purpose. The drawing tools are the same as in Word, but the whole picture may be copied and inserted by a click into a Word paragraph. The figure got by this way fits into the paragraph within the margins and, it may be re-sized or e.g. framed if necessary. A further advantage of PowerPoint-made figures is that their original file may be used for PPT presentations if authors

should present their work anywhere. An example of a figure made by PowerPoint is to be seen below.

The literature sources of tables or figures, or a reference to the own design should be given as well. This requires another text style or, preferably, a reference number as it is to be seen above.

D. Footnotes and references

Studies may contain such references which are not in a close contact with the text but, they are necessary to further explanations or references. These texts, data or references should be put into footnotes. The style of footnotes (e.g. the place, row height, character size etc.) is not only important for an attractive image of a page but for the readability as well.²

If authors of project plans or feasibility studies use theoretical or empirical sources from the professional literature, references are necessary to follow the rights of intellectual property. The references should follow usual patterns where the authors' name, the issue date, title of the source material and all of additional bibliographical data are given. The form of a list of references should given according to a sample text style as well. Authors usually should fulfil the promoters' requirements with this respect as well.

V. SUCCESS FACTORS OF PROPOSAL WRITING

The two general phases of a proposal writing are the preparatory works and the elaboration of proposal itself. In order to be successful in a tendering process, however, a third phase is to be taken into consideration as well. This phase is the evaluation of proposal. Although this is not the task of applicant, the aspects of evaluation influence the whole proposal writing work. It is important therefore that applicants get experiences in a process of evaluation and they perceive their chances in a tender [7, 8, 20].

A. Positive attitude and high performance

First of all, applicant thoroughly should study the call for tender. All of important informations, especially the requirements and premises, should be taken into consideration.

The preparatory works for proposal writing should be focused - furthermore - on conceiving the real and attractive contents and claims of project and, on the key parts of feasibility. Early in this phase, applicant should search for fundraising supports, because this aspect requires time and efforts [19, 20].

In the planning phase of proposal, the applicant's introduction is relevant in order to gain confidence from the option writer - e.g. from the promoter. The introduction should show all of necessary capabilities to realize the project in question.

Applicant should search for such project partners which are reliable and attractive enough to gain together an order or a support. The most successful choice is if applicant has positive experiences with this partner from former successful projects or other business co-operations. The issue and its argumentation is a further factor of attractivity and confidence [19].

The content of project and, based on it, the budget estimations are the most extensive and pretense part of proposal, with

special respect to the reality and sustainability of the whole project. Special respect should be done to the harmony between the intentions and capabilities of applicant. The professionalism of project plan is a leading factor in a decision about award an order or a financial support [19, 22].

The economic and social impacts should be elaborated by the way that their reality may transparently be seen and pre-calculated.

A rich set of literature and trainings about proposal writing is offered by consulting and training firms and, furthermore, by different webpages on the Internet. These opportunities should thoroughly be studied in order to choose the best professional support for the success [4, 5, 9, 12, 13, 23].

B. Traps to be avoided

During the preparatory works, applicants should avoid the mistakes deriving from failing or misinterpreted informations.

The underestimated need of resources may lead to a low level time and financial budget which negatively impacts on the feasibility or sustainability of project [15, 18].

The lack of adequate fundraising informations or sources are crucial concerning the funding success. This may lead to delay of implementation or, in a more problematic case, to the financial fiasco of the project in general or, of the institution itself.

The lack of own capital force, of adequate project partners or of supporting institutions may result in that a key financing partner denies the necessary support. In this case, applicant may be in a situation of forcing to withdraw the implementation of the whole project [19].

Finally, inadequate elaboration or, neglected aspects of anticipated long range, wide spread benefits should be avoided in the course of elaboration of a proposal.

C. Aspects of evaluation to be concerned

The evaluation of proposal - first of all - concerns the applicant's authenticity and background. Therefore, the introductory chapter of proposal should underline the professionalism and reliability of applicant. The CVs of professional people e.g. are convincing attachments to the proposal. Further aspects and preferences of evaluation are presented in the table 2 below.

TABLE 2
ASPECTS AND PREFERENCES OF PROJECT EVALUATION

ASPECTS	PREFERENCES OF EVALUATION
Tendering deadline	Generally, this is an absolute criterion of acceptance of an application
Turnaround time of the project	It should be short enough to utilize the chances but it should remain within the frames of reality
Scarce resources and their allocation	Promising partnerships are preferred in the financment and implementation
Risks of delay	Applicants should present effective and efficient risk management tools
Opportunity costs	Feasibility studies should contain calculations of opportunity costs in the case of project fiasco or delay Causes and inhibition of barriers should be presented

² This is an example of how to insert footnotes and, how to use an appropriate footnote style.

ASPECTS	PREFERENCES OF EVALUATION
Business benefits of project	Payoff calculations should be made, based on correct market forecasts
Social and cultural impacts	Positive impacts on detrimental areas, social groups or persons should be presented Cultural impacts should be emphasized
Opportunity of dissemination	Impact of partnerships, impacts of results on other areas, targeted actions of dissemination should be anticipated.

Among the aspects of contents and quality, the entirety and professionalism of proposal are relevant factors of success. Because of it, a short overview should show strong signs of professionalism and, in the executive summary, these signs should be emphasized as stressed as possible [22]. The formulation and layout of proposal can be further success factors.

If the rationality of contents and, the utility of project is well emphasized in the study, this may reinforce the success of evaluation.

VI. TRAININGS FOR PROPOSAL WRITING

A rich background of literature focuses on the management of training process, publishing practical proposals [4, 5, 12, 13, 23]. In our consulting works, we elaborated and tested a specific, three-phase training program with pre-programmed criteria, leading questions and fill-in blanks in order to offer support for proposal writers, especially for institutions of agricultural education.

In our training practice, trainer divides participants in creative teams of 3–4 people per each one and hands out an application form to each group. This step will be repeated in each of three phases. The groups then receive a short explanation of contents, questions and tasks of each step [19, 20].

A. Target-oriented segmentation

As we mentioned beforehand, the success of a proposal writing depend on three general phases: on the preparatory works, on the elaboration of a tendering study and, on the evaluation by a tendering body. Consequently, the trainings have to concern each of these phases as well. Trainings should make the applicants able to fulfil the requirements of each of these phases.

In the first phase, participants should guess a case of development project for business or social purposes. At the next two phases they should continue the work on the same case. Each team’s following task is the casting according to the team members’ professional areas. Participants decide the key aspects of the development project chosen. They should formulate premises, forecasts, anticipations. It is vital that they are able to explain why did they choose a particular approach to a particular planning aspect and how it will influence their subsequent steps in project planning and implementation supposed [19].

B. How to write a good summary

Various project studies should contain an executive summary. The purpose of it is to shortly inform promoter about the key aspects and parts of project. The idealistic place of this

chapter is behind the list of content, in order to give a short, immediate set of key informations in advance.

The summary has two relevant purposes:

- to establish the evaluation and,
- to inform promoter about the necessary decisions or intervention.

The attribute „executive“ refers to these key purposes. The summary should inform executive persons of tendering body, in order to evaluate the whole project concept according to the anticipations and premises.

The extent of summary should be – as mentioned before – between 3–5 pages. In the case of a more extended or sophisticated project, however, a longer summary may be required and acceptable.

The executive summary – similar to the business plans or feasibility studies – focuses to the purpose, key parts, resource needs, financial and time budget, benefits, sustainability and long term advantages of a project. These parts should be abstracted from the chapters of the study in question, preferably in this logical sequence.

In the summary, all of critical factors of each step should be noted, with special respect to the financial and time budget. Because the feasibility depends on the fundraising success, applicant should emphasize the variants of its factors in the executive summary as well [20].

The second purpose of summary is to inform tendering body about the necessary decisions or intervention, facing with during the implementation. This is necessary in the case of disturbing or impeding conditions. Finally, the executive summary should underline the feasibility, attractiveness and long-range benefits of the project, supporting by the project concept.

VII. USE OF A PROJECT SCENARIO

The core of a development idea is a positive imagination about business or social benefits which concern broad circles of areas or people. This may be directed to physical, technical, environmental or intellectual development, with special respect to knowledge, life standard and life style of people, preferably of whole societies.

As these imaginations formulate themselves into mission statements, the purpose becomes more and more concrete. From the mission statement derive the technical, financial and human aspects of a project.

The general development projects usually are complex and sophisticated. They are driven by different stakeholders’ interests. The steps of their implementation is full of technical, organizational and financial details: tasks, deadlines and influencing factors. These contents may, however, be drafted into a consistent pattern of logical trees which show the parallel paths of realization [15, 18].

Each path of realization may represent a module of implementation, with a key purpose, with leading thoughts – principles, goals, targets and actions. The actions themselves are complex sets of tasks, deadlines, preconditions and responsible persons.

Tasks may be grouped according to their character or, according to the project purposes. The first categorization is to be offered because of the success of task. This means the tasks

may be of technical, financial, human, organizational or complex character and, the success of implementing a task mainly depend on the professionalism, ability and intention of person concerned [20].

In the case of complex tasks, however, a manifold professionalism, interdisciplinary skills are required. Participants of a project planning team should draw up a set of tasks in the plan of implementation, detailing them according to their targets and professional requirements.

VIII. FINAL CONCLUSIONS

In the course of our so-called “Tender-fit training”, trainer should emphasize the fact that the PPT presentation and the application form are – generally – very-very simplified, focusing the essence of successful contents and level of proposal. These training materials are, however, useful tools in calling the attention for the most usual lacks and traps, leading to unsuccessful proposals.

The phase of evaluation of proposal writing trainings should apply similar criteria as those used in real tendering processes. The simplified cases do not permit to neglect the key aspects of evaluation [19, 22]. A proposed framework of criteria of training evaluation is presented in Fig. 6. below.

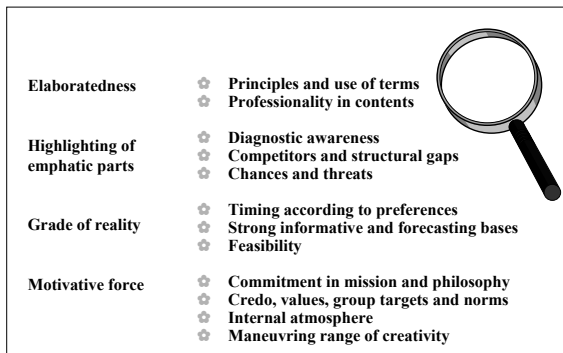


Fig. 6. Aspects of evaluation of tender-fit trainings [15].

Trainee participants of a proposal writing training should be assured that – among others – the third phase, the evaluation will more deeply establish the key success factors of a competitive proposal.

This training material is our an intellectual property, developed within the frames of Europrofessional EC and Agistra Studio EC – to different target groups, for different purposes. Similar training games may be made and offered if needed, to establish long-range proposal writing and project planning developments.

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SCIENCE AND ENGINEERING RESEARCH: ASSESSMENT METHODS

J.K.Kiplagat and P.K.Rotich
Western University of Science and Technology
P.O. Box 190. Kakamega. Kenya.

Abstract-The evaluation of research and indeed any aspect of science and engineering is a complex process. Engineering research encompasses a wide range of creative, theoretical and practical activities involving many communities within a country and beyond. Such diversity, both in the communities of interest that science and engineering serves, and in the character of the research itself, poses a number of challenges to the assessment of excellence.

All those responsible for the funding of public research, across the globe, are re-examining the methods traditionally used to assess research quality. Government funded research agencies are increasingly under pressure to justify their share of tax-payers' money.

Meanwhile, research, particularly engineering research, is becoming increasingly more interdisciplinary, carried out by a wider set of practitioners, whose interests include simple wealth creation and academic excellence. It is in this complex, dynamic environment that the essential differences between science and engineering are sometimes overlooked.

This paper therefore presents in simple terms what we consider to be general principles for the assessment of excellence in science and engineering research, adaptable to different needs.

I INTRODUCTION

The bridge between science and its exploitation through technology to enhance wealth creation and quality of life is engineering research. It embraces a balanced portfolio of capabilities and activities, which serve the needs of many different communities including small firms, large firms, government bodies, academia and other interest groups. Research groups achieve excellence through a combination of high quality disciplinary and interdisciplinary work. To reward and encourage productive engineering research, quality assessment mechanisms need to consider comprehensively the ways in which research is taken forward and made useful to the different user groups.

Excellence in engineering is identified by five characteristics - including, but not limited to, the quality of

published research findings - and that it is in the combination of these characteristics that excellence in engineering is to be found. Ideally the assessment methods should be applicable to a research group, programme or department in order to capture both single discipline and interdisciplinary research activities.

The paper begins with some essential definitions and moves on to state what is understood by research excellence in relation to science and engineering whether activities are carried out by small research teams or larger research groups working on a number of projects. These definitions provide a universal foundation on which to base the assessment and the determination of excellence. Following an account of current methods, an outline assessment process is described which can be developed to provide a robust and comprehensive methodology for assessment of excellence in science and engineering research.

II RELATIONSHIPS BETWEEN ENGINEERING, SCIENCE AND TECHNOLOGY

The nature of the relationship between engineering and science continues to be debated. From an engineering perspective,^[1] science is viewed as knowledge that results from use of a scientific method to further understanding. In contrast, engineering not only seeks understanding but also creates devices and systems to meet human needs.

From this perspective, engineering impacts on society through the creative application of science.[1] Engineering is the process of assembling knowledge and experience to create machines, devices, systems, structures, processes and products to meet human needs and to improve and extend those previously created. Engineering research seeks fundamental understanding to improve the engineering process. The ultimate output of engineering research is the development of new or improved techniques and processes for creating machines and devices etc., with better specifications and/or lower costs, and the machines and devices etc. themselves - in short, technology.

Science is the knowledge and understanding of the character and behavior of everything that exists, be it natural or manmade. This knowledge and understanding is obtained through observation and experiment - the scientific method.

Science does not have practical use as a necessary objective - whereas engineering always does. The output of science is also, frequently, technology. Scientific knowledge and the scientific method are basic elements of engineering research.[2]

Basic scientific research provides us with information, which, though previously unknown, only offers hints of the future. It is the engineer who can take these theories and basic building blocks and from them create technology. Technology comes from employing and manipulating science into concepts, processes and devices. These in turn can be used to make our life or work more efficient, convenient and powerful.

So it is technology, as an outgrowth of science, which fuels the industrial engine. And it is engineers, not scientists, who make technology happen. An essential aspect of engineering is concerned with impact on society through wealth creation and improvement to the quality of life. High quality engineering research whilst producing scientific knowledge also produces a complex set of outputs that address particular social and economic needs. These are found in the development of the networks and processes that constitute the means of exploitation. These dimensions distinguish engineering research from scientific research.

In summary, successful engineering research will produce outputs -and processes that are relatively difficult to separate from the context of application in industry, government or any other section of society. The challenge for policymakers is to develop quality assessment mechanisms that measure the broad range of engineering research outputs that are relevant to a number of different user communities.

III CHARACTERISTICS OF EXCELLENCE IN SCIENCE/ENGINEERING RESEARCH

From an engineering perspective, there are several elements, which need to be considered when determining the overall measure of excellence in the research process.

Five characteristics of excellence in engineering research are identified:-

A Strategy: directing the focus and scope of research activities. Strategic planning and resource management determines the eventual impact of engineering research; how the work is taken forward to its selected community or communities of interest; and the programme for developing excellence in the other four characteristics of engineering excellence.

B Science-base research: focusing on the creation of new scientific knowledge needed to underpin novel and innovative engineering devices and processes. Here attention is normally focused on single-disciplinary problems which are set and solved by the largely academic community, and are

communicated through institutional channels [3] (e.g. publications) and driven by curiosity and the desire to create new insights. A country with an engineering base that is weak in the production of science-base research will be relatively ill placed to develop the radical innovations that spring from new scientific knowledge.

C Engineering-base research: impacting on society through the enhancement of wealth creation and quality of life by producing knowledge in the context of application in non-academic and academic activities which may be single or interdisciplinary in nature.

This type of research manifests itself ultimately through people-centered activities, (for example, the provision of advice, the appearance of new products, processes, start-up companies and collaborative networks) and scholarship. A lack of engineering-base research will fundamentally undermine the strength of the engineering research base, not simply in the application of new knowledge but also in the production of new research.

D Scholarship: high-standard, independent, science-base and engineering-base research, free of financial and political control, to promote the well-being of society. Scholarship pervades academia but is separated out here to identify one key aspect, namely independence. There is need to protect those interests that are not served by wealth creation alone (safety, environmental impact, academic freedom) and to safeguard the integrity of engineering as an independent and trusted source of knowledge and advice.

E Vitality and Sustainability: the vitality of the research group is a function of the group size and strength, quality of the researchers, interdisciplinary activity and the essential supporting infrastructure, such as equipment, administrative and technical support.

Collaborative capabilities and involvement in professional networks that cross-institutional and organizational boundaries are also essential to the vitality of the group. Sustainability requires development and maintenance of capabilities that support continued learning and participation in activities associated with diffusion of knowledge and public understanding.

Continued learning includes research and support staff training (and its continued refreshment) and career development. Sustaining research excellence requires that the core research staff have secure positions to allow a long-term focus on research projects and that the diverse backgrounds of society are represented so that the different individual insights can contribute to innovative solutions to a wide range of problems.

An engineering research group that suffers from a lack of vitality and sustainability will not have the strength to collaborate with its user communities and will therefore not be able to develop the usefulness and relevance of its technologies.

IV REVIEW OF CURRENT METHODS FOR SCIENCE AND ENGINEERING RESEARCH ASSESSMENT

A Research Assessment Exercise

Many countries have a national body charged with the responsibility of conducting research assessment exercise. Often times it is the most comprehensive method available for assessing the relative strengths of university research. It addresses the following aspects: publication quality from named journals; originality of research; the research environment; vision; international visibility of staff and published work; national visibility and impact of the department; industrial collaboration; national and international awards and earnings.

The Research Assessment Exercise could be enhanced by: Improving the consistency between the different engineering panels in the way that the guidelines are applied; crediting the exploitation of research results, particularly where industry is a partner; recognizing the difference between science and engineering research outputs and including the contributions which engineering research makes to the development of innovative products and processes.

B Professional Bodies Assessments

Professional Scientific or Engineering Societies often undertake assessment of research. The quality of the research is assessed in four ways: Intrinsic excellence of the research in world terms; the extent to which the output of trained staff meets the requirements of employers; the potential for the research output to have a wider impact on other research and the potential for the research to contribute to the country's wealth creation and quality of life through new or improved products, processes or services. This output provides a useful input to business planning processes, as well as meaningful information for stakeholders, including the academic community.

Through analyzing quality in terms of intrinsic excellence, employability and potential impact on research, wealth creation and quality of life, this methodology addresses, in part, some of the characteristics in section 3.

C International Assessments

An important emerging feature of assessment processes is the involvement of internationally recognized experts.

Overseas organizations and international technology policy documents need to be consulted to identify best practice in other countries. Many countries are giving consideration to the problem of how to measure the quality of research when a significant proportion of the outputs cannot be reduced to academic papers. The main point is that there is an increasing recognition that research in engineering and the applied sciences demands quality assessment methods that differ from those traditionally used to assess the pure sciences.

D. Mathematical and Statistical methods

The application of mathematical and statistical methods to assessment of research involves a range of indicators directed at quantifying research output as indicated by data derived

from scientific literature (including patents). The techniques may include the number of papers issued by a country, by institution, by author, or the number of citations. However, these indicators cannot perfectly capture all knowledge production and inform us of its quality. This is due to a number of factors.

Firstly, published papers are the result of laboratory activity. Other innovative activities are not published to the same degree. Secondly, papers cannot contain all the knowledge produced in research, which also has tacit and material elements that cannot be communicated through publication channels. Thirdly, these indicators do not represent all publishing. Fourthly, citations cannot tell us about the quality of a piece of research.

E Overview of Current Status

Current assessment methods with the characteristics outlined in Section 3 reveal that none of the current assessment methods address all aspects of research excellence. There is need to develop a comprehensive set of measures to assess and encourage excellence in engineering research. Two further issues also need to be considered.

Firstly, certain assessment processes are frequently based on the university department, reflecting the fact that university departments are normally organized around individual disciplines at undergraduate level. However, research can be both single and interdisciplinary in nature requiring an assessment process, which is sufficiently flexible to address both aspects.

Secondly, it is important that engineering research can be assessed on both a national and international basis. The national assessment is required primarily to assist in the responsible distribution of Government research funding and to provide useful evidence to help the user communities to decide where to place the own resources. The international assessment is required to provide reassurance that the quality and quantity of academic engineering research is fully competitive with that of other countries.

V DEVELOPMENT AND USE OF THE ASSESSMENT PROCESS

Assessment processes usually measure outputs. However, research outputs particularly in engineering base research can be difficult to identify and measure and there is often considerable time delay between their production and subsequent use in society. Therefore the approach proposed is to focus on developing a set of measures which address the five characteristics identified in section 3 above, which together ensure that the research will have the desired impact on society. This is considered to be a far more robust approach than to rely solely or largely on publications.

If research is to have the desired impact on society it must do much more than produce publications. It must follow a strategy to develop the appropriate science-base research, engineering-base research, scholarship and vitality and sustainability necessary to impact upon the needs of the

identified communities of interest. Only by recognizing these five characteristics in combination, will policy makers stimulate and reward excellence in a way that impacts on improving wealth creation and quality of life in society.

To reward and encourage productive engineering research, quality assessment measures need to look beyond the indicators that are relevant to the academic community (e.g. publications) by considering the research outputs in relationship to the various communities that use the results. A typical set of measures is shown in Table1, which indicates the appropriateness of the measures to the characteristics of the research process.

The table highlights the applicability of different types of possible indicators for assessing the five characteristics of the research process. For example, publications are more appropriate measure of quality in science-base research than in engineering-base research.

TABLE 1
APPROPRIATENESS OF MEASURES TO THE CHARACTERISTICS OF THE RESEARCH PROCESS

Characteristics	Determines Impact on Wealth Creation and Quality of Life				
	A	B	C	D	E
<i>Measures</i>					
Publications	X	Z	Y		X
Peer Recognition	X	X	Y		X
Consultation		X	Y		X
Evidence of Partnerships Industrial Support and Partnering Activities		X		X	X
Patents and Practical Research Outputs		X			X
Independence Indicators			X		X
Core and Support Capability Indicators					X
Involvement with Society Indicators					X
Strategic Programme and Resource Planning Indicators	X	X	X	X	X

A-Science-base research
B-Engineering-base research
C-Scholarship
D-Vitality and Sustainability
E-Strategy

X-Highly appropriate
Y-Fairly appropriate
Z-Possibly appropriate

Each set of measures shown in the table has a number of components. This is because measures of the quality and relevance of research activities have to be made with respect to the nature of the research and the user groups the research aims to serve.

A Proposed Components of the Assessment of Research

Publications: Academic publications, conference publications and trade publications.

Peer Recognition: Professional recognition, international prizes, awards and honors

Consultation: Advisory committee membership, advisory services to Government/large business/small business/charities/pressure groups, consultancy reports,

activities and processes, partnering activities, collaborative programmes, (number and funding), conference chairs, conference participation, personnel exchanges, workshop hosting and external-open seminars.

Research output: Patents, licenses, novel processes, products and spin offs/start-ups, proportion of research funded/not funded by industry.

Core and Support Capability: Number of trained researchers and PhD students, staff indicators, experience, willingness to collaborate, teaching and presentation skills (qualifications and training): Percentage research staff positions (permanent and part time), staff and student training and career development activities (number, quality and relevance) and employability, infrastructure quality and relevance, technical support staff (number and qualifications), number of administrative support staff and qualifications/experience.

Involvement with Society Indicators: Number of staff/students engaged in public understanding activities, number of media articles/broadcasts related to research and number of staff with media relations responsibilities.

Strategic Programme and Resource Planning Indicators: Research strategy relevant to chosen mission and purpose, evidence of efficient budget management and quality of strategic management and planning evidence.

VI THE ASSESSMENT METHODOLOGY

This paper proposes a concept for measuring excellence in science and engineering research, which, it is believed, can be applied across all the scientific disciplines. However it is fully recognized that the concept needs to be developed further to become a workable process. In particular, it is necessary to produce well-defined guidelines in order to ensure uniformity of approach. The process can be used to assess research groups or departments whilst those measures, which relate to programmes can also be used in this context. This assessment process is applied to research groups or departments; it has a number of essential elements:

1. A research group needs to identify its strategy, as outlined in Section 3, which includes a short piece of text that identifies its user communities. This is may be done with the help of a 300-word statement that describes the mission of the department.

2. Quality measures are assembled using the components, such as those listed above that are most suited to the user communities identified by the research group.

3. An assessment is made using the qualitative and quantitative measures that are assembled using these components, with peer review – including acknowledged experts from industry as well as academia - playing a central role.

The use of such an assessment methodology thus enables the formation of a clear link between policy objectives and the direction of research aimed towards particular user communities. It also fits well in a policy environment that

utilizes multiple funding streams to support stability and the pursuit of different policy objectives.

There are many advantages to the assessment methodology presented in this paper. Firstly, a robust assessment mechanism that values and rewards the broad range of outputs of engineering research will encourage researchers to focus their efforts on new research results and innovative solutions to problems that are of relevance to a broad range of communities, including those in industry and academia. Secondly this type of assessment process, by asking engineering research groups to identify, in a strategy statement, their particular communities of interest, gives policymakers an idea of the relative strengths of the country's innovation system in relation to large firms, small firms, government, academia and other sections of society that have the strongest involvement with engineering in the country.

VII CONCLUSIONS

Engineering research provides the knowledge that underpins the process of exploiting the science base. The application of technology to products and processes results in an impact on society through advancements in wealth creation and quality of life.

Engineering, like other applied sciences, serves a variety of well-defined communities of interest: (for example large and small companies, the government, and today's and tomorrow's society). High quality engineering research groups produce new knowledge that cannot be separated from the context of its application, requiring researchers to develop links with those communities wishing to exploit the results.

There is a need for a single widely accepted process, applicable to research groups, programmes or faculties, which addresses all the characteristics that determine excellence in science and engineering research

Research must be assessed on an international as well as a national level to enable valid comparisons to be drawn on the true quality and value of the research effort. International experience must therefore feature in the assessment process, involving overseas assessors and supported by adequate financial resources.

Peer review - including acknowledged experts from industry as well as academia - is a well-respected method of assessing those aspects of research that are not readily amenable to quantitative measures and should therefore form part of the assessment process.

The methodology proposed in this paper addresses the demands of measuring science and engineering research excellence. The use of characteristics, measures and components helps to the identify research groups that are best meeting the needs of their specific user communities.

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ISSUES IN THE EVALUATION OF A PROGRAM TO PROVIDE ASSISTANCE TO SCIENCE TEACHERS IN INNER-CITY SECONDARY SCHOOLS

Jack Victor, Victor Associates, 82-25 218th Street, Hollis Hills, NY 11427
Magued Iskander, Ph.D., PE, Polytechnic University, Brooklyn, NY 11201

Abstract – Revitalizing Achievement by using Instrumentation in Science Education (RAISE) is an NSF funded program in which undergraduate and graduate engineering students (Fellows) assist high school science teachers, using sensor-based experiments as laboratory exercises to test concepts taught in the classroom. Fellows assist the teachers in presenting the labs and checking that students understand their assignments. Fellows are also utilized to help teachers in other ways such as clarifying concepts taught in class and to assure that students working in groups were following their assignments properly and understood the main concepts involved. Initial analysis of grades and test scores of students involved in RAISE after the first year of the program have not shown any major academic changes or differences that can be attributed to the project. Issues involved in making such comparisons in a real-life setting are raised in the paper.

Questionnaire data from the high school students and their teachers do suggest that there have been positive effects. These are reflected in the students judging the RAISE contributions to the class – the sensor-based experiments and the Fellow – as having positive educational value. There also are some indications that RAISE class students seem more interested in science than their counterparts in non-RAISE related classes and that they value having a Fellow involved in future science classes.

The high school teachers are generally supportive of the program, find the Fellows quite useful in a variety of ways and rate the sensor-based laboratory exercises as effective. The majority of teachers recommend participation in the program to other teachers. Fellows, too, recommend the program to other university students. They generally have found the program a rewarding experience that has helped them in developing their own science skills and most would be interested in continuing the experience.

I. INTRODUCTION

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 teacher. RAISE Fellows have been employed in Living Environment, Active and Regents Physics, Marine Science, Forensics, 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].

The project is supported through a grant from the National Science Foundation (NSF). The goal is to better motivate high school students toward a greater interest in and, therefore, higher achievement in science courses. The initiative comes at a time when there is wide acknowledgement that science education in the United States needs improvement. For example, at a time when new discoveries in science, technology and engineering are generating new potential for progress, the US is falling behind in the production of graduates in these fields. In fact, US engineering graduates have declined 20% over the last 20 years. Secondary school students are unprepared in math and science and, consequently, are uninterested in pursuing these careers [2].

The project, therefore, addresses the need to supplement the limited resources available for teaching science effectively [3] and increase learning of science in secondary schools. One problem with science education that has been identified is that courses in secondary schools are presented unimaginatively. [4].

The purpose of Project RAISE is to improve performance and increase the interest of high school students in science. The program also exposes college students to opportunities to articulate and solidify what has been learned in their development as scientists and engineers and to engender interest among promising college graduate and

undergraduate students in the possibility of teaching as a future career option. Finally, RAISE seeks to improve the performance of the cooperating high school teachers by providing them with another knowledgeable person in the classroom and by introducing new technologies aimed at stimulating more interest in the content of courses.

II. EVALUATION OVERVIEW

As stated, the program was designed to affect all three constituencies involved: the high school students, the college students and the high school teachers. Accordingly, evaluation was designed to provide data on all of these effects. Thus, students could be assessed in terms of available class grades or Regents test performance. However, other indicators had to be created, which has presented difficulty in identifying the types of data that will accurately reflect the impact of the program. These include how the students felt about the effectiveness of the main inputs of Project RAISE--namely the sensor-based experiments and the presence of the Fellows. They were also asked questions concerning their interest in science, mathematics and engineering, and the extent to which their science class has influenced this interest. The teachers were asked how they felt that the main inputs of project RAISE affected the course and the extent to which the program was helpful to their students and themselves. The Fellows were asked their impressions of the success of the program and the extent to which the experience was meaningful to them in their own development as scientists/engineers. Thus, in addition to collecting grade and Regents test data, questionnaires were developed to assess each constituency. Virtually all Fellows were observed twice per semester by the evaluator to provide an additional perspective on their in-class performance.

III. ACADEMIC PERFORMANCE

At the onset of the program, data on the final grades and Regents test scores for the class previous to the advent of the RAISE program were collected to use as a baseline. At the end of each year, this same data was collected for RAISE classes and for classes studying the same subjects but not involved in RAISE. This would seem to be a straightforward process, but actual implementation of this procedure proved to be challenging for the following reasons:

- 1) Of the four schools that started the program, one school was reorganized, which led to the selection of another school as a replacement. Thus, baseline information for the replacement school began one year later than baseline for the other schools.
- 2) One of the three schools that was with the program in its first year had transformed in the year in which Project RAISE was introduced from what was primarily a junior high school to regular high school status. This change was accompanied by a major turnover in

administrators and teachers. Thus, grades were not available for baseline. Regents scores from the year previous to the project are of questionable value because the makeup of the students taking them were quite different when compared to the students entering the school for the first year of the project. For this school the differences between grades given in the first marking period were compared to grades given at the end of the term. There was little difference found for Active Physics, but there was a positive change for Living Environment students. However, it is typical of New York City high schools for teachers to mark more strictly for the first marking period to provide a warning to students to improve their work, so that change by marking period is not a useful comparison. Unfortunately, there were too few students at this school to permit comparison to non-RAISE classes. Thus there was only one Active Physics class and one Living Environment class, both of which were involved in the RAISE program. This situation will change in year two for Living Environment classes.

- 3) A third school claimed, at the time that baseline information was collected, that the group that took the Regents examination that year performed at an unusually high level relative to the average performance of that school in previous years.

Other problems included the way in which classes are formed. In some schools, classes are heterogeneous; in others they consist mostly of higher or lower performing students. The school's organizational pattern was difficult to discern, but this appeared to be the case when one analyzed comparative performances of baseline data by class, which showed some substantial differences between classes and even between some classes where the teacher was the same.

Another issue was the nature of the comparison class. One might think that comparing RAISE class to non-RAISE class with the same teacher might be a useful comparison because the teacher difference is controlled. However, once the program was instituted, it is probable that much of the learning by the teacher from the Project RAISE class was utilized in his/her other classes, thus contaminating the comparisons. Comparisons between the same teacher from baseline to project year would seem to be a more useful comparison.

When comparing baseline to end of first year grades for students at the two schools where this was possible, no program effects were yielded with one exception. There was a positive change at one of the schools in Regents Physics standardized test scores. However, this may be explained by selectivity. In the baseline year, twice the number of students took the exam than the number who took the exam at the end of the first project year. Thus, students who were not strong may not have been encouraged to take the exam.

The one school, which claimed that their baseline Living Environment class was relatively high performing, showed differences in favor of the baseline class for both grades and Regents scores. In the other school, mean grades for the baseline year in Active Physics actually exceeded the mean grade for the end of the project year.

Another problem arose in one school in which Regents Physics grades were compared from one year to another. The grading system was changed from numerical grades for the baseline year to Pass/Fail in the first year of Project RAISE, which complicated any comparison of data.

In terms of comparing RAISE and non-RAISE classes for the first year of the project, some of the results were positive, but again raise questions. Mean grades and Regents scores for Living Environment students at one of the schools exceeded those of non-RAISE classes taught by the same teacher. However, the RAISE class is considered an "honors" class and, thus, there likely were students enrolled who tended to be more conscientious, if not abler. This difference did not occur at the other school, where non-RAISE students had a slightly higher mean grade. There are no comparison classes available for Regents Physics and only one of the two schools offered Active Physics. RAISE-related Active Physics class grades were actually higher than the non-RAISE related classes.

Thus, there is little evidence thus far from academic grades and Regents test scores to indicate that the program has had a positive impact on student performance in the first year. Analysis of second year data is taking place now and preliminarily seems to show a more positive result. However, some of the measurement problems cited in the above discussion will also affect the findings for the second year.

These measurement problems can be summarized as follows:

- 1) Comparing baseline to subsequent classes assumes equality of student ability between years. In two of the schools, this equality can be questioned.
- 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.

IV. NON-ACADEMIC STUDENT OUTCOMES

There was an attempt to measure other changes through the use of a questionnaire. A draft questionnaire was developed

to examine certain issues selected by the evaluator after discussion with project management and the science department chairs of the cooperating high schools. As the program developed, other ideas were suggested at meetings with representatives of all of the constituencies involved with the program. These suggestions were incorporated in the questionnaire. In addition to the questionnaire, it was suggested that the program increased interest in the class, which could be reflected in greater attendance. An attempt was made to obtain attendance records, but a review of this data revealed the information to be subject to great teacher variability regarding when attendance was checked, so these data were dropped as a variable.

The main outcome questions posed to the students were as follows:

- Is interest in science affected by the course? In particular, how do the students feel about the experiments with sensors and the presence of the Fellow – the two main ingredients of the program?
- In addition to the outcome measures, the questionnaires offer the opportunity to gather process information by asking about strengths and weakness of the course and recommendations for how it might be changed to increase their attention.

In the first year, it was possible to distribute the questionnaire to RAISE and non-RAISE students taking the same course at the same school. As mentioned above, however, this was possible only with respect to Living Environment courses at two of the three schools. The major findings from this questionnaire were as follows:

1. Living Environment students in RAISE classes at both schools, showed a greater interest in studying science, math and/or engineering in college than students did in comparable non-RAISE classes.
2. There was no difference between RAISE and non-RAISE students in terms of the effect of their current science class on interest in science, mathematics and/or engineering.
3. Students in all RAISE classes rated labs with sensors as being more valuable to their learning than labs that did not use sensors as a tool for learning.
4. A large majority of students in RAISE classes perceived the Fellows to offer high educational value.
5. In most RAISE classes, the overwhelming majority of students expressed interest in having the Fellow work with them in future science classes.
6. Living Environment and Regents Physics students at one school and Active Physics students at another did not agree that the Fellow provided much or very much educational value.
7. The same Living Environment and Regents Physics students as in finding 6, did not show a high interest in

having the fellow work with them in future science classes.

8. There was no difference between RAISE and non-RAISE students with respect to the impact of their current science class on developing their interest in science, mathematics or engineering.

Thus, there were findings suggesting a positive effect of the program on students, yet not all of the results were positive.

V. OUTCOMES FOR TEACHERS

Questionnaires were developed for teachers to measure how they perceived the value of the program and to derive specific ways in which the program changed them. The key questions posed to teachers were:

- areas where the Fellow was helpful (or not helpful);
- ratings of the effectiveness of the sensors and Logger Pro resources;
- ratings of the effectiveness of Project RAISE on achievement in their classes;
- ratings of the extent to which they would recommend the program to other science teachers.

Major findings were:

- 1) Teachers overwhelmingly noted seven areas where Fellows were of assistance to them and their students. These were: (1) explaining concepts to the students; (2) providing useful lab exercises; (3) ensuring understanding of tasks for students involved in group work; (4) functioning as positive role model; (5) providing information on science and/or engineering; (6) improving classroom attendance; and (7) improving laboratory attendance.
- 2) A large majority of teachers also felt that the Fellows helped to keep students more attentive.
- 3) The majority of teachers rated the sensors and Logger Pro resources as effective or very effective as laboratory resources.
- 4) A large majority of teachers rated the RAISE program, as a whole, as very effective or effective.
- 5) A large majority of the teachers would recommend the program to other teachers without reservation.
- 6) There were a few teachers for whom the experience with RAISE was not altogether positive. These teachers expressed: (1) lack of positive feelings on the effectiveness of the program in general, (2) some reservations on the effectiveness of the sensors and Logger Pro resource, and (3) unwillingness to recommend the program to other teachers without reservation.

While not unanimous, a large majority of the teachers did feel that the program was very helpful to them in a variety of ways.

VI. OUTCOMES FOR FELLOWS

Key questions for the Fellows were:

- areas where the Fellows felt themselves to be helpful (or not helpful);
- effectiveness of the laboratory experiments that they presented;
- value of serving in a high school as a personal learning experience;
- effectiveness of the relationship between the Fellows and the high school students;
- interest in teaching science;
- interest in participating in the program in the future;
- extent to which they would recommend participation in the program to other university students.

In general, reactions by the vast majority of Fellows were consistent with the responses made by the teachers.

- 1) They felt that they had been helpful or very helpful in six areas: (1) teaching science concepts; (2) introducing laboratory exercises; (3) working with students in groups; (4) providing a positive role model for the high school students; (5) providing information on science and engineering; and (6) keeping students more attentive.
- 2) All of the Fellows felt that the lab experiments that they presented were effective or very effective.
- 3) A majority of Fellows felt that the schools to which they were assigned provided a positive learning experience to their students.
- 4) A majority of the Fellows felt that students (1) respected them, (2) found them helpful, (3) were interested in maintaining a friendly relationship with the Fellows, and that (4) communication with students was easy.
- 5) Fellows overwhelmingly felt that experience with Project RAISE was helpful in developing their own science knowledge and skills.
- 6) Several Fellows did express interest in becoming science teachers and none rejected the possibility outright. Three of the Fellows responded that they would consider the possibility of teaching at the secondary school level.
- 7) The overwhelming majority of Fellows indicated interest in continuing their participation in Project RAISE in the following year (and most have).
- 8) All of the Fellows would recommend the program to other university students.
- 9) A majority of Fellows, but not all, felt (as did the teachers), that they were helpful in improving classroom and laboratory attendance.

- 10) Several Fellows had reservations concerning recommending participation in Project RAISE to other university students. Essentially the reservation was that participation meant that they had to be ready to experience “hard work.”

It is not surprising that the Fellows were positive about the program since such a rating is, in part, a self-evaluation. However, they did feel that the project was helpful in developing their own science skills and there was considerable interest among the Fellows about the possibility of teaching in the future, although only a few would consider teaching secondary school.

VII. ISSUES CONCERNING USE OF QUESTIONNAIRES

Questionnaires present problems especially when using them with populations not accustomed to responding to them. While inner-city high school students are often given tests, attitude questionnaires are rarely administered to this group. In constructing the questionnaires, careful attention was paid to using vocabulary that would not create a problem for students at the levels of those being queried. At the same time, questions should be constructed with precise enough language to avoid misinterpretation. These two considerations are sometimes in conflict.

In this regard, for example, students were asked whether anyone in their immediate family worked in science, mathematics or engineering. The intent was to elicit responses concerning the relative influence of father, mother, or siblings on their interest in science. However, both the term “immediate family” and the concept of occupations involved in science, math and engineering were broader in interpretation than intended. Respondents reported on the involvement of their uncles, aunts and cousins and fields in which they were involved ranged from doctors and engineers to auto mechanics, accountants and construction workers.

The use of scales by students had some idiosyncrasies and so revealed some inconsistencies where similar or seemingly related questions were presented. Prime examples of this are in regard to two questions that would seem to be related. Students were asked to (1) rate how much they learned because of assistance from the Fellow and (2) to rate the extent to which they would like to have the Fellow working with them in future science classes. Answers received from one class revealed six students who had checked that they had learned much or very much from the assistance by the Fellow, but replied “maybe” or “no” to the question as to whether or not they would want to have the Fellow work with them in future science classes. While one could conceive of possible reasons for this, the likelihood of these conflicting pair of responses occurring so frequently raises questions regarding validity of their answers.

In another question ratings were provided in terms of amount of agreement with a statement. Several students responded to all of the questions with the same degree of agreement despite the fact that many of the questions were constructed in such a way that the positive or negative direction of the questions were reversed. These response biases have been reported in the literature. [5]

VIII. ENRICHING THE QUESTIONNAIRES

Meetings of project leadership, teacher representatives, the Fellows, school liaisons and the evaluator discussed directions that could be pursued to determine other positive outcomes that could be occurring and which the evaluation had not as yet considered. Of the ideas generated, two were deemed to be especially worthy of merit and possible to include in the evaluation methodology. These were:

- measurement of attitudes toward science that might have been experienced by the students;
- addition of a number of variables to measure the effect of the project on the Fellow.

The student questionnaire was therefore amended for year two by introducing items extracted from scales [6] concerning attitudes toward science. Fellows questionnaires were expanded to include the following information:

- the extent to which the experience has helped them in developing their own science skills;
- the extent to which participation in the program affected decisions about graduate school;
- the extent to which participation has resulted in greater participation in conferences, journals, etc.

IX. OTHER EVALUATIVE ISSUES

In addition to the test and questionnaire data, there have been more informal assessment procedures used. Issues that emerged in carrying out the program are raised at regular meetings of teachers, administrators and fellows. Science department chairs visit the classrooms and speak to the teachers and Fellows about progress.

The evaluator conducts two observations for most or all of the RAISE classes – once in the fall and once in the spring. The evaluator then prepares a report on the observations to project leadership. The overall impression from these observations is that the Fellows and teachers seem to be working well together and that the Fellows, seem for the most part, to have the respect of the students. Fellows seem to be especially useful in presenting and monitoring the sensor-based experiments and in making sure that the students understand and carry out the assignments. They also seem to be helpful in clarifying concepts for the students. The advantage of having an explanation coming from a different perspective than that of the teacher is helpful for students who may not grasp the concept at first.

The Fellows often can relate better to real life examples than some of the teachers.

The working relationships between Fellows and teachers are not uniform and some teachers utilize the Fellows more than others. This utilization seems to depend on a multiplicity of factors – the willingness of the teacher to share responsibility; the ability of the Fellow to take over more responsibility; and the maturity of the students in the classes. The most important factor regarding the maturity of the students is the presence of proper decorum in the classes. Some students have difficulty with self-control; some teachers are better than others at gaining the attention and respect of students. There are differences in this regard among the Fellows, as well, who are called upon to develop skills which reinforce attentiveness and good deportment.

The three schools that have continued in this program from the first year are schools whose students are generally not high performing. In the second year, a school was added whose students generally perform better. It could be that more progress will be seen for those students as compared to students where disinterest in the educational process is so great that the inputs involved in the project are insufficient to affect significant academic change. Also, perhaps the process involved in RAISE may improve with time. Seven of the twelve Fellows from the first year were involved in the second year as well. Most of the same teachers have remained involved at the cooperating high schools. From observation, nearly all of the Fellows observed in the second year who were involved in the first year seem to be more comfortable in the classrooms and provide leadership for new Fellows. Moreover, teachers who had been with the program in the previous year seem more comfortable about utilizing the assistance of the Fellows.

An issue that was of some concern when the project started was the match between the Fellows and the students. Students in two of the three schools involved with the project in the first year are mostly African-American. Students in the third school involved from the beginning are generally Latino. None of the Fellows were from these backgrounds. They are primarily immigrant or first generation Americans whose heritage is Far Eastern, Southern Asian or Slavic. However, this difference did not seem to be a factor. Students seem to relate positively to the Fellows without regard to ethnicity or national origin. There were only one or two instances involving Fellows where some of the high school students expressed difficulty with understanding their speech. This was rare, however.

X. CONCLUSIONS

The purpose of this paper is to point out challenges in assessing the effects of intervention on science education in selected inner-city secondary schools. The experience with evaluating Project RAISE was described, and issues were discussed concerning the difficulty of obtaining meaningful comparative data using either baseline comparisons to

current grades and test results, or to comparison groups. Many situations occur that interfere with providing an ideal setting for such comparisons as the school carries out its day-to-day educational program. Also discussed were the problems of interpreting questionnaire responses from students who are not accustomed to responding to attitude instruments.

While academic data has not shown positive change due to the program, data has been analyzed for only the first year. Moreover, data from questionnaires suggests that the program has been of considerable value to the high school students, their teachers and the Polytechnic University Fellows who have participated in the program. Moreover, preliminary analysis of year two data is promising and seems to point to measurable academic gains as the program continues and matures.

XI. ACKNOWLEDGEMENTS

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Synchronous e-Learning: Three Perspectives

J.A. Redmond

A. Parkinson

A. Mullally

D. Dolan

Department of Computer Science

Trinity College

Dublin 2

Ireland

Contact: redmond@cs.tcd.ie

Abstract- Synchronous e-Learning is not well-described in the literature. A common complaint is that there is an absence of reported research in the area. Here are given the summary results from a number of synchronous eLearning pilot studies presented from student, lecturer and administrative perspectives.

I. INTRODUCTION

Synchronous learning has some important advantages over asynchronous learning such as immediate feedback, more motivation and the obligation to be present and participate [1]. Despite the varied benefits of synchronous learning, there is a lack of andragogical research in the area [1].

This study examines empirical studies pertaining to the area of synchronous learning. The purpose is to elucidate insights from the experiences of three synchronous learning studies and the results from an eLearning survey.

Online Synchronous learning can be defined as: a real-time, instructor-led online learning event in which all participants are logged on at the same time and communicate directly with each other [2]. In this virtual classroom setting, the instructor maintains control of the interaction with the class, with the ability to "call on" participants. On most platforms, students and teachers can use an electronic "whiteboard" to see work in progress and share knowledge. Interaction may also occur via audio- or video-conferencing, Internet telephony, or two-way live broadcasts.

Asynchronous learning can be defined as: learning in which interaction between instructors and students occurs intermittently with a time delay [3].

II. WEB-BASED COLLABORATIVE PLATFORMS (WCPs)

A typical collaborative platform has most or all of the following:

- Two-way audio and video conferencing
- Application sharing

- Interactive whiteboards
- Synchronized Web browsing
- PowerPoint slide facility
- Instructor-led floor control
- Electronic hand raising, feedback and Q &As
- Group text chat
- View student screens
- Breakout groups
- Voice over IP (VoIP)
- Participation meters
- Viewable class lists
- Multi-platform
- Multimedia courseware with third-party authoring support
- Classes can be recorded, edited and stored for later playback, instantly creating self-paced content for student review or for instructor training.

III. DESCRIPTION OF LEARNING ENVIRONMENT

The lecturer and students operate in a virtual "classroom". The virtual campus is modeled on a physical college campus in that it provides administrative functions with registration of students for courses, course creation, class creation, adding of course materials and assigning lecturers to lectures. The virtual classroom provides an environment with whiteboard area, synchronized web browser, application sharing, text chat, hand raising, questions and answers, feedback, attendance list and an agenda for the class.

A participating student should be equipped with a computer conforming to at least the minimum specification as set out by the CP supplier and a network connection fast enough to support the server connection [4]. Students are also required to have downloaded the client software. The testing of audio levels before a lecture session was vital to the smooth running of a student's connectivity. This enabled them to check their earphones and microphone.

IV. STUDIES

A. The Two Genius Studies

The Genius project was funded under the European Union GENIUS (Generic E-Learning Environments for the new Pan-European Information and Communication Technologies Curricula) programme [5]. The overall purpose of the project was to explore the real-life practical issues associated with applying a web-based collaborative platform, LearnLinc [6], embodying both synchronous and asynchronous dimensions. The purpose of these two pilot studies was to investigate practical and operational aspects and issues to do with using such a tool-set.

On the first part of the project, a Trinity College Dublin, (Ireland) staff member (DD) presented a course entitled "IT and the Enterprise" to a group of mature, evening attendance, computer-literate, undergraduate Information Systems students. Of this cohort of students more than 76% worked with computers greater than 30 hours per week. This course was evaluated using pre- and post-questionnaires

A number of weeks later another member of TCD staff, (AM) presented a second course entitled "Managing the IS/IT Infrastructure" from the TCD base to a group of forty M.Sc. Computer Science students at the University of Reading in the UK. This was evaluated in a similar manner as previously [5].

B. The SPOT+ Study

In a recent survey (Students perceptions of the use of ICT in university learning and teaching available at http://www.spotplus.odl.org/downloads/Survey_report_final.pdf) carried out as part of the SPOT+ project (Students' perspective on technology in teaching and learning in European universities (<http://www.spotplus.odl.org/>) funded by the DG for Education and Culture of the European Commission), 2,000 students from 12 different universities in Europe surveyed were interested in the use of Information and Communication Technologies (ICT), defined as audio-visuals, computer programs and Internet, for information exchange, but expressed a stronger preference for traditional education methods. Just over half the respondents were 21 - 25 years old, and 30% were 16 - 20 years old. All respondents were students at rather similar universities of an older and research-oriented type [7].

With respect to explicit learning purposes the students expressed a stronger preference for traditional education methods (defined as printed text and a classroom setting) than for ICT-based methods. If ICT is to be used in an educational context, students specifically expressed doubts about the quality of the human interaction when there is no face-to-facecontact.

C. An Evaluation of a Presentation Experience from Cisse 2005

Cisse 2005 was a web-based international conference run by the University of Bridgeport and the IEEE. About 250

participants presented papers including this group from TCD [4]. The eLearning sub-conference was the International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE 05) and ran from December 10-20, 2005.

This conference was a very good eLearning experience. It was interesting to see the recurrence of many of the problems which had occurred in the earlier pilot studies run in TCD.

iVocalize [8] did not have as many facilities as LearnLinc. Animated slides for example did not work on this occasion and presentations needed to cater for this. However the conference did demonstrate the feasibility of a world-wide web conference, even if many of the participants interacted via a 56 kb line.

In the Cisse 05 conference where the team was presenting a paper, a considerable amount of pre-lecture work was necessary to use the system effectively. Firstly the team needed to become familiar with the iVocalize system; the Powerpoint slides to be used in the presentation had to be uploaded to the server. Next the sound level had to be set properly by going online to check this.

During this phase, it was discovered that iVocalize had problems working on Apple machines on this occasion and could not provide full functionality. Other Apple users had similar difficulties.

It was also discovered during the practice sessions that iVocalise could not handle the animation of slides. Later, during the conference, with about 250 presentations, there were some difficulties which meant that the Powerpoint slides had to be uploaded again just before the presentation.

It became obvious during the paper presentations that those who had not completed a number of practice sessions had difficulties in delivery; many of the difficulties were due to sound volume levels, being set either too low or too high.

It should be noted that the presenter was a highly experienced lecturer of long-standing, and an award winner for teaching excellence, who has an excellent reputation for generating a good rapport with his classes. He also gave some of the sessions in the previously mentioned Genius study. The comments did not reflect upon the skills of the presenter but on the constraints of the Web Collaborative Platform.

The authors of this paper also took part in the Cisse 2005 presentation [4]. Two of the authors (AP/ JAR) had not directly taken part in a Synchronised Learning experiment previously, other than in a training mode. Subsequent to the Cisse presentation, they evaluated the presentation and gave the following comments.:

Presentation: The presentation was felt to be stilted. It was considered that this experienced lecturer would have performed better if he had experience of a broadcasting medium such as radio broadcasting or podcasting where lack of immediate feedback is an essential feature of the medium.

The presentation, of necessity, had a very high dependency on text and audio. However, it was hampered and impoverished because the lecturer was unable to interpret inter-personal cues due to the lack of feedback which is a characteristic of the medium. This contrasts with the normal traditional lecture/ classroom session. Immediately afterwards the presenter found it difficult to evaluate his own performance. Again this is considered to be due to a lack of feedback.

Co-presentation: There was no opportunity for co-presentation of the material in parallel, although it was necessary for a second person to be present to quickly solve any problems arising from the use of the interface. (For instance, there was one presenter and his assistant but only one microphone).

Feedback: There was little feedback from listeners in attendance at the Web conference because it was quite difficult to ask questions anyway but time constraints due to any presentation difficulties dramatically reduced the question time window. Insightful commentary by others was limited by the virtual audience who had all not mastered the technology enough to be able to use it effectively. The medium is such that the presenter feels under pressure to deliver all as quickly as possible as he/she gets no audience reaction. In a traditional lecture the presenter would not be under such time pressure as audience feedback helps modify the delivery of the presentation.

Human Computer Interface: What was noticeable was how restricted the human computer interface was. It was also noticeable that iVocalize was more restricted than the LearnLinc interface used in the Genius studies. There was little facility for the accommodation of Individual Differences (e.g. changing the colours (for Daltonism), icons, font size (for sight impairment)). The virtual whiteboard wasn't really used as a whiteboard but as a slide presenting board. There should have been another to function as a real whiteboard (cf. LearnLinc).

The medium forces the presenter to try to be all-complete. There will be little chance for covering missing points later. No opportunity arises naturally other than the somewhat inadequate question and answer session at the end of the presentation.

The medium showed some improvement on a telephone conversation where the two participants have copies of the paper and slides. A telephone conversation is duplex whereas this medium is half-duplex and devoid of any visual stimuli ("walkie-talkie" mode).

What is of most interest is the similarity between many of the findings of the Genius studies and those from the Cisse 05 evaluation.

V. THREE PERSPECTIVES

The key features of Synchronous Learning are looked at from three perspectives - those of Student, Lecturer and Administrator. These perspectives are informed by the

results from the two Genius studies, the SPOT+ study and the study done on the presentation for Cisse 05.

A. STUDENT PERSPECTIVE

Practice Sessions: The students need a couple of live practice sessions to familiarize themselves with the interface and its quirks. It seems for all the synchronous packages that there is a lot to learn and that getting the audio level right may prove difficult.

Software Installation: Generally the students are required to install some software from the WCP Supplier.

Audio Level: A major problem with WCPs is that the audio level of the computer needs to be set at a proper level. This may be a non-trivial problem with no easy solution.

Machine & Network Specification: The user must ensure that his/her machine is up to the specification necessary for the Web-based Collaboration Platform. This may involve not alone upgrading the computer but also the communication line speed. In general broadband is necessary and the faster the speed the better.

Student Reactions to Sessions: A number of student comments were that the lectures were boring. The student is not in contact directly. The student has to concentrate and listen intensely. This is fatiguing over a 50-minute lecture period. There is too much potential for distraction. There is a lack of face to face contact. Students have found it difficult to ask questions. This contrasts with a face to face lecture environment where a question serves as a means for the student to reaffirm the current level of understanding of a topic.

The following are some of the comments after the Pilot Study:

"I would like to see it applied to a very technical course i.e. programming, where tutorial and exercises could be done individually or by a group simultaneously".

"I'm not sure I actually remember the material as well from the online lecture as I did from a traditional session. I think I rely on visual cues for remembering more than I realised".

"The experience has been positive. The length of time reasonable. I wouldn't have liked to continue taking my lectures using the method the whole academic year".

"It was surprising the amount of people in the class who were against this technology. Also a large number were unable to cope with any problems on their own."

"I enjoyed the experience, found I prefer traditional style lectures, and glad I had the experience".

B. LECTURER PERSPECTIVE

It is well-known that Synchronous Learning needs a redevelopment of content rather than just presenting traditional lecture notes online. Perhaps the content needs to be more interspersed with dialogue and other forms of interaction. How much information flow is optimal for Synchronous learning? There is more information flow in

a face-to-face teaching situation than in a synchronous learning situation.

It is important for the lecturer to keep a continuous speaking level with no big pauses. Large pauses in delivery lead the participants to wonder if the system has gone down. It is important to speak relatively slowly and distinctly. Some participants may not be native English speakers, so it is necessary to give a relatively slow, but measured delivery. Lecture delivery is constrained quite a bit by the medium and inadequacies of the human computer interface of the WCP.

Ideally eLearning should be based on a judicious blend of Synchronous, Face-to-face (traditional lecture, seminar etc.) and Asynchronous Learning. One lecturer's comment was that Synchronous Learning was fine if presented at intervals but not continuously over a whole course. It works well with faster broadband; 56k modem is way too slow resulting in the need for impoverishing slides to reduce the bandwidth demands.

Another lecturer commented that in a traditional lecture room, the lecturer is able to exploit the sensory modalities to enhance the learning experience, but this is not so with a WCP (e.g. it is difficult to use humour to establish a rapport with the class; it is difficult to create an atmosphere conducive to learning).

Apart from the computer on which the Lecturer is presenting the course, one Lecturer, from his experience, commented that the Lecturers need a machine which shows what the student is seeing (which may be different from what the Lecturer is seeing on his machine).

A conclusion from the various studies suggests that two lecturers are much better than one, and support each other in a dynamic manner analogous to the two presenters on a TV sports commentary. One commentator on his/her own tends to be overwhelmed and generates long pauses which are irritating to the audience.

This leads on to two computers on the dais (Lecturer machine; Student machine); two screens for the Lecturer machine (one for presentation; one for observing the student body via still photos)); two lecturers for a better presentation without pauses with both lecturers supporting each other.

C. ADMINISTRATOR PERSPECTIVE

There are quite a number of important factors pertinent to the administration of a synchronous learning system as evidenced by the number of studies discussed above

Cost of planning and preparation: The synchronous learning exercise has to be planned far in advance (3 - 6 months) in order to train technicians to set up and run the exercise. The lecturing staff, like the technicians, also need training.

Software licensing cost: Software must be licensed in advance for the desired number of seats. The software must be set up along with any necessary supporting software for the exercise. The cost of licenses for the Genius exercise was relatively expensive in a university context. The

maintenance and upgrade costs of the software needs to be considered in the longer-term.

Training cost: Quite a considerable amount of training is necessary to run the exercise. Technicians need to be trained to support the exercise. This technician training may involve a couple of days at a supplier site. This could cost of the order of \$5,000.

Those who will lecture using the synchronous package also need to be trained, usually locally by the trained technicians. This might take two days.

Setup: Much time and effort is necessary to assemble the hardware and install the software.

Staffing costs: Expert technical support needs to be available on call during live sessions; a minimum of one technician is necessary. Similarly two members of staff, rather than one, are much more effective. This additional member of staff may seriously affect the cost benefit model of synchronous learning.

Equipment provision and upgrading: Equipment, software and network speeds may need to be continually upgraded at considerable cost.

Additional hardware: Apart from the student machines, at least two machines are necessary for the presenters on their dais.

Location provision: A well-equipped location for the presenters' dais is necessary.

VI. DISCUSSION

The traditional learning environment is rich in interpersonal communication punctuated with non-verbal cues which greatly assist and enrich the learning process. The dynamics of group learning can be effectively managed by an experienced teacher/ lecturer which can elucidate the nuances of the subject matter being learnt. These types of interactions can be adjusted to accomplish individual and group learning goals [1] [9].

In a traditional learning environment it can be argued that the learning process is founded on a well-established pedagogy. This serves to inform best practice [1].

Just suppose we want to calibrate today's traditional learning environment with that of a current synchronous learning environment. What would be necessary would be to enclose each student in the class in a cardboard box so that he/she could not hear or interact with his peers but could see the whiteboard and hear the lecturer through a slot (for the eyes and ears) in the front of the box. The student would have to operate cognitively at a fast pace while concentrating intensely so as to accommodate the next salient piece of information. In other words, learning was experienced by many of the students in these studies in a stimulus-starved environment.

There is no doubt that there is a great future for synchronous eLearning if the above problems can be effectively addressed. Normal teaching capacity might not be able to cope with the training load in industry. For instance in the UK it was stated in 2004 that four million managers needed to be trained in ICT skills [10].

In a traditional classroom environment twenty years from now one might reasonably expect that integrated computer technology be available to enhance these learning environments. Just image a scenario in the year 2026 where every classroom will have an individualized student workstation at each desk/ seat. This will comprise whiteboard facilities; internet access to relevant databases and access to live video conferencing technologies. It would be envisaged that each of these workstations could be easily established subject to monitoring by a teacher/ lecturer. In this envisaged environment, the student – teacher interaction will still remain paramount and pivotal to the learning process.

What might the future hold for synchronous learning? Assuming a blue skies scenario where most, if not all, ICT problems have been solved. There is now plenty of cheap memory, processors speeds are very high, broadband will be extremely fast and very good quality web camera will be available cheaply. Perhaps virtual reality packages in 3 dimensions will have lived up to their promise.

The issue to be considered here is whether this virtual synchronous learning environment will be as good as today's traditional classroom or indeed the traditional classroom enhanced twenty years from now.

The answer to this scenario is difficult to predict because of

- the lack of an established andragogy. In other words, there is no definitive, empirically proven ways for deploying synchronous learning technology today [1].
- Approaches appear not to have taken into account the characteristics of the mature learner i.e. vast, varied experience; self-direction (high levels of intrinsic motivation); one might also assume cognitive maturation and significant time constraints.
- More fundamentally the most crucial issue remains how best can synchronous learning enact the richness of the personal and non-interpersonal communication present in individual classrooms today. The evidence emanating from the three perspectives given earlier in this paper ably demonstrates that this may be the over-riding deficit in synchronous learning today with its all of its negative ramifications.

In addition to the issues discussed above, there are still some topics that should be addressed, such as:

What topics? This medium is more suitable for the dissemination of declarative knowledge.

What blend? As part of a course, a reasonable question is whether synchronous could encompass the whole course or just part of it? This is an open question. Some feedback from students suggest that face-to-face interaction is a necessary component of any course irrespective of the andragogical strategy deployed (e.g. groupwork, individualization [11], one-to-one, applications broadcast model etc.).

What is a suitable presentation mode? Can course presentation in a synchronous medium be presented in ways to accommodate individual differences such as

cognitive styles, memory, variety of experiences.? This question is particularly relevant when one characterises the older learner. Some of these characteristics would include: a disposition for self-directed learning, cognitive maturation, a vast array of past experiences and, in some cases, the every day reality of the importance of time management.

Cultural Nuances? Can the interface allow for the customisation/ localization of course content to accommodate cultural differences? [12].

Necessary computer literacy skills? What is the minimal level of computer literacy required to successfully function within a synchronous environment perhaps ECDL or equivalent [13].

Is there an optimal HCI design for synchronous learning? What features are necessary? What features are desirable?

Webcam?: Webcam facilities would have helped but at great cost in bandwidth so they were probably infeasible anyway without fast broadband. A webcam would also reduce the potential audience of a worldwide conference dramatically. A webcam also raises issues about who and how many should be displayed at any one time.

Open Source Software? A reliable, well-test tested Open Source Collaborative Platform is desirable particularly for andragogical applications. In this context, a consideration of appropriate system type is necessary. Should such a system be designed on non-adaptive or adaptive system paradigms? [14].

VII. SUGGESTIONS FOR THE FUTURE

- Open source collaborative platform
- Better HCI interface
- A more, enriched, perhaps multi-media based content.
- Alternative applications with real-time evaluation of performance e.g. instructor training
 - Better interface design resulting in less cognitive overload from the perspectives of both lecturer and student.
 - Better audio facilities such as autosegging of audio level
 - Genius 2 is being planned based on the previous pilot studies.
- Empirically based usability studies are necessary so as to help produce better WCPs.

Similar weakness in Web-based Collaborative Platforms identified by these studies need to be addressed in the design of future, enhanced WCPs.

One unexpected result of these studies is a much deeper appreciation of exactly how much is involved in the "traditional" lecturing environment.

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A Framework for Benchmarking Arabic Verb Morphological Tools

Sane M Yagi

University of Sharjah,
Sharjah, U.A.E.
saneyagi@yahoo.com

Jim Yaghi

Macquarie University,
Sydney, NSW, Australia.
jim@leptobyte.com

Abstract—Arabic morphology tools are numerous, but there have been no standard tests of performance with which success and extent of coverage can be gauged. Much of the testing has been done by developers in accordance with ad hoc standards of their own. Although many claim success, users remain skeptical of the efficiency and level of coverage. In this study, we discuss the problems that Arabic morphological tools need to address in order to be considered successful, and describe a test set that we are advancing as a proposal for golden standards for computational Arabic verb morphology.

Index Terms—Arabic morphology, computational linguistics, assessment, gold standards, test data, test set

1 INTRODUCTION

Much of the attention in Arabic computational linguistics has been directed at Arabic morphology. However, there is little unanimity in the community on how best to assess the accuracy and reliability of the developed algorithms. Here we discuss a framework for benchmarking Arabic verb morphology tools and propose a gold standards list that future tools may use to assess their algorithms.

Test sets are designed to gauge the performance of NLP systems and are subsequently standardized to ensure that developed systems meet requirements. Unfortunately, Arabic morphological tools have not undergone such rigorous evaluation, and have often been subjected to non-objective assessment.

Indeed, a survey performed by [1] showed that over 66% of experts in Mediterranean countries assessed their Arabic language resources internally, while 13% did not use any validation at all. Here are some examples of assessment methods used in previous works:

An Arabic morphological transducer in [2] was tested with 115 verbs, 10 nouns and adjectives, and the full range of closed classes of prepositions, particles, and modal verbs.

A two-level system in [3] was tested against a set of 100 test cases hand picked to represent strong and weak verbs equally. He ensured no solutions for weak verbs affected solutions for strong verbs.

In [4], tests were made of an augmented transition network (ATN) system on texts from various sources and the authors were satisfied with the ATN exhaustive search. They decided that their lexical analysis system demonstrated that it could

find all possible interpretations of an inflected Arabic word on the basis of its performance over hand-picked sample texts.

Each of these works contributes valuably to the discipline whether or not it captures the entire spectrum of Arabic morphological system; each demonstrates yet another technique at differing costs in training, speed, and accuracy. However, it is not possible to compare their performance against one another or to assess the degree of their success. The question remains, how representative of the morphological system was the test data? As long as the answer is not clear, one may speculate as to the value of any solution.

Little effort has been made towards establishing benchmarks for testing Arabic morphological tools. In this work, we make a modest attempt to launch into discussion of morphological system benchmarking and the issue of standardization.

Ref. [5] proposed that an Arabic morphological analysis system be able to analyze the classical Arabic language; all its words whether vowelless, semi-vowelless, or non-vowelless; be efficient in data retrieval and storage; be fast in data processing, and be capable of handling multiple users.

When surveying Arabic corpus analysis tools, Ref. [6] found that most of the systems were not available for testing or were difficult to use. Often input needed to be transliterated or reformatted. There was also no agreement on what the output of an Arabic morphological analyzer should look like. Some would add vowels to unvowelless texts, some would find roots and affixes, some would add morphosyntactic features, and others would add part-of-speech tags.

Having given some examples of assessment methods used by Arabic computational morphologists, it is necessary now to comment on what golden standards lists ought to be like.

Ref. [7] discussed setting up gold standards for Portuguese and proposed a pre-structured dataset of inflected forms. The authors gained consensus by inviting contributions to the list and refined it for coverage and frequency weighting. Each entry was accompanied by a category label indicating its morphological features. The resulting list was 655 entries.

Before the Linguistic Data Consortium (LDC) annotated Chinese databanks, no standards existed for assessing the performance of word identification systems. However, there is disagreement in [8] with the use of a single score to evaluate a word segmenter's efficiency. A suggestion was made that mul-

tiple human judges be used since disagreement between humans is expected.

Good test data according to [9] anticipate all possible stumbling blocks that may stump a system. Authors suggest that test data represent real and hypothetical data, typical and extreme cases, and legal and illegal instances.

2 ARABIC MORPHOLOGY

Arabic is a member of the Afro-Asiatic language family. Distinguishing characteristics of this language group are the non-concatinative derivational morphology and inflectional syntax. Although the interaction between Arabic morphology and syntax is complicated, it is nonetheless regular. Additional complexity derives from the morphophonemic interaction. Languages in this family have much in common, but their orthography is diverse. Arabic's orthography adds yet another level of complexity.

Morphological analysis refers to the decomposition of words into morphemes. In concatenative derivation, words are formed by chaining morphemes together. Arabic, on the other hand, forms words from morphemes by fusing them together using infixation or reduplication. Arabic's syntax is classified as inflectional because words change form depending on their grammatical function.

2.1 Roots

Derivation in Arabic is performed by combining a root with a template. The root is a semantic abstraction consisting of consonants and semi-vowels. These sounds in a root are commonly referred to as root radicals. Arabic verbs are derived either from trilateral roots (three radicals) or quadrilateral roots (four radicals). In this paper, we represent these in order as First (**F**), Medial (**M**), and Last (**L**) radicals when it is a trilateral, and append a Quad final (**Q**) radical for quadrilateral roots.

Words derived from the same root have the same basic morphemic and semantic attributes with the root as their common base. For example, the root {**k,t,b**}¹ is loosely linked with a meaning related to 'writing'. From it, we can derive words for 'book' (*kitAb*), 'desk' (*makotab*), 'library' (*makotabap*), correspondence (*mukAtabap*), 'subscription' (*AikotitAb*), and so on.

Phonotactic rules constrain how root radicals may combine. For example, the Obligatory Contour Principle (OCP) on place of articulation restricts the occurrence of similar sounds within a root. Ref. [10] states that the adjacency of radicals in root-initial position is restricted within the group of labial obstruents (*b,f,m*), coronal obstruents (*t,d,T,D*), dorsals (*k,q*), and gutturals (*x,g,H,E,h,'*). The dorsals are restricted from co-occurrence even in non-adjacent positions. Identical sounds may occur adjacently but only in non-initial position. Sonorants (*l,n,r,w,y*), on the other-hand, may occur in any position.

¹ Arabic letters are transliterated using the Buckwalter orthographic scheme (<http://www.cis.upenn.edu/~cis639/arabic/info/translit-chart.html>).

2.2 Patterns

Morphosemantic template patterns fuse with roots to cast a derived word into a particular abstract semantic orientation. These are combined with morphosyntactic templates to further concretize the word and place it into a particular syntactic category. Morphosemantic patterns consist of a combination of constant and variable elements much like an algebraic equation. Root radicals slot into the variable positions in the template and they then often interdigitate with the neighboring constant elements of the pattern. The resulting string is still not a word but a stem because it still has an abstract meaning but is more concrete than the root. The final derived word is formed by inflecting the stem grammatically. As an example, consider the two roots {*b,s,l*} 'to relate to scowling', and {*b,S,r*} 'to relate to discernment'. We mold them into the morphosemantic template **FaMuL** 'to develop a personal quality', and we obtain the stems in Table 1. Note, however, that the bold letters in the template are its variables indicating the First, Medial, and Last trilateral root radicals. Actual letters need to be slotted in these positions.

F a M u L	to develop a personal quality
<i>b a s u l</i>	<i>to develop a scowl</i>
<i>b a S u r</i>	<i>to develop discernment</i>

The morphosemantic pattern **FaMoMaL** meaning 'to induce an action or quality' when applied to the same two roots {*b,s,l*} and {*b,s,r*} generates respectively **bas~al** 'to induce a scowl' and **baS~ar** 'to induce discernment'. These templates create an augmented root or a stem that contains a level of semantic abstraction. They become words once they get fused with a morphosyntactic pattern that attributes to the stem a syntactic function. Verbs must be marked for the categories of subject, person, number, gender, tense or aspect, mood, and voice. The patterns **FaMuL** and **FaMoMaL** used above can be conjugated to produce, for example, such syntactically marked patterns as in Table 2.

A root may be molded into morphosemantic patterns to generate as many as 45 different dictionary entries² but with the aid of morphosyntactic patterns it can generate hundreds of words (inflected stems) that loosely share the same semantic content. By our calculation, Al-Waseet Dictionary [11] can be used to generate over 2 million inflected verbs. The number of inflected noun stems would be even higher.

2.3 Cliticization

Inflected stems can still be affixed with clitics which may be conjoins, particles, and pronouns. Proclitics attach to the front of an inflected stem and include two conjunctions (*wa* 'and', *fa* 'next'), an expository particle (*li* 'in order to'), a homographic particle (*la* used for consequentiality, emphasis, or imperative-ness), a future particle (*sa*), and a yes/no interrogative particle (*>a*). Enclitics which attach at the end are three types: a set of subject pronouns, a set of 12 object pronouns excluding homographs, and a particle for intensification which has two allographs: (*n~a* and *na* 'certainly').

² As counted by us in one of the standard modern dictionaries, Ref. [11].

Clitics may be strung together such that an inflected word may have zero or more proclitics and/or enclitics. They do cause minor orthographic or morphophonemic changes to inflected words.

TABLE 2.
WORD DERIVATION USING MORPHOSEMANTIC + MORPHOSYNTACTIC PATTERNS

Inflection	Morphosemantic	Morphosyntactic
3 rd pers sing fem active perfect	FaMuL <i>to develop</i>	FaMuLato <i>she developed</i>
		basulato <i>she developed a scowl</i>
		baSurato <i>she developed discernment</i>
	FaMoMaL <i>to induce</i>	FaMoMaLato <i>she induced</i>
		bas-alato <i>she induced a scowl</i>
		baS-arato <i>she induced discernment</i>
3 rd pers plural fem active imperfect	FaMuL <i>to develop</i>	taFoMuLun~a <i>you develop</i>
		tabosulun~a <i>you develop a scowl</i>
		taboSurun~a <i>you induce discernment</i>
	FaMoMiL <i>to induce</i>	tuFaMoMiLun~a <i>you induce</i>
		tubas-ilun~a <i>you induce a scowl</i>
		tubaS-irun~a <i>you induce discernment</i>

3 FEATURES OF ITEMS IN THE LIST OF GOLD STANDARDS

A gold standard in the context of morphological data testing is an agreed standard set of root-word pairs manually matched or verified by linguists that is representative of the full morphological spectrum. Either the root or word half of the set is offered as input to the assessed morphological system, then its output is checked against the other half of the standard dataset. A score is assigned on the basis of the degree of similarity between the correct solutions from the gold standard list and the results given by the new tool. The score may then be used to empirically determine and compare the validity of the system to the ideal or to other systems using the same standard dataset.

The test set that becomes a gold standard must be both valid and verifiable. Validity means that the pairing of roots to words is known to be an accurate representation of Arabic morphological knowledge [12]. It would also be necessary to verify that the pairings are encompassing of all root categories, morphosemantic and morphosyntactic patterns, morphophonemic processes, orthographic transformations, subject-pronominal and object pronominal affixation, and cliticization.

The two primary factors that are responsible for Arabic's rich and vast lexicon are the classification scheme of roots and the systematic generation processes that target specific root types in morphophonemic and orthographic contexts. Traditionally, roots are categorized by derivationality, phonemic typology of their radicals, and number of radicals. If roots are properly classified, all morphological rules may be targeted at very specific root types. For example, phonetic contexts are essential for morphophonemic processes that handle phonetic assimila-

tion, deletion, and insertion. Orthographic rules apply to well-defined phonological contexts. Similarly, rules for affixation are targeted at certain phonotactic contexts.

Roots can be separated into categories based on the number of radicals, whether or not they contain morphophonemic transformation prone or inducing root radicals, and the position and number of such radicals. Traditional classification recognizes tens of such classes, but only ten have been given formal labels.

A valid morphological system must be able to handle each and every root type and process that morphemes may undergo.

Systems must also be capable of generating, analyzing, and/or tagging all verbs in the language. Tools that have a larger gap in their coverage should be recognized as being of lower quality. These tools must not generate or analyze non-existent or unused words, neither should their computational processing result in non-existent roots.

Although verbs can be generated by molding roots into 44 morphosemantic verbal patterns, native speakers of Arabic generate only a small set of verbs from each root. Different selections of morphosemantic patterns are used with each root. Seventy one percent of the roots with verbs use 1-4 morphosemantic patterns, while 5% use 8-13 patterns. Generating every word possible from all 44 patterns for each root would surely produce every word in the language, but will also result in a lot of non-existent (although theoretically correct) words. Systems that acknowledge such non-existent verbs will have a high rate of false positives.

So a morphological tool must reject words such as *basotan* 'to plant in a garden'. This word's root could be considered to be $\{b,s,t,n\}$, a legitimate root used in the language with three sub-entries in the dictionary. The radicals may be found to be interdigitated with the morphosemantic pattern FaMoLaL, a legitimate and highly productive verb pattern of the language. However, despite conforming correctly to all the derivation rules from an existing root and pattern, this verb has never been created in the language; i.e., it constitutes a lexical gap. A computational morphological system should not derive or analyze verbs that constitute lexical gaps.

Similarly, systems should not accept words generated using non-existent roots or morphological patterns even if they are processed by valid rules. For example, *basotam* is legally derived from the root $\{b,s,t,m\}$ and pattern FaMoLaL. However, $\{b,s,t,m\}$ as a root does not exist in Arabic, and such a verb should be rejected by a computational morphological analyzer.

Over the ages, multiple forms were developed for the same morphosemantic patterns, and these made their way into classical Arabic. Valid morphological analysis tools should acknowledge these variants because they form an important part of the language knowledge. In some cases, multiple forms of the same morphological pattern for the same root have become associated with very different meanings. For example, the root $\{H,w,l\}$ 'to relate to change' when interdigitated with the morphosemantic pattern $>aFoMaL$ 'to acquire a quality' derives both the verbs $>Howala$ 'to become cross-eyed' and $>aHAla$ 'to relegate or to refer'. In other cases, derived from the same root and morphosemantic pattern are two variants that mean the same thing, e.g., *AistaHowa*a* and *AistaHA*a* 'to become in

control'. Good morphological systems are capable of identifying morphological variants because they commonly appear in real Arabic texts.

3.1 Morphophonemic Transformation

The alterations that affect root radicals during word generation are induced by morphophonemic transformation. This process dictates how morphemes change structure when sounds that are prone to change combine with others. The phonetic phenomena of assimilation and dissimilation responsible for these changes developed over time to ease articulation. Sometimes, one sound may affect the previous or next sound, while at other times, two similar neighboring sounds grow apart and become different. Commonly, semi-vowels are most responsible and prone to morphophonemic alteration, and so are h, d, >, t, T, and m.

Assimilation causes letters to get deleted, inserted, replaced, or transposed resulting in major change to the structure of words, often rendering their patterns and roots unrecognizable. The examples in Table 3 show the impact of semi-vowel transformation on word structure.

TABLE 3. SEMI-VOWEL ALTERATIONS

Root+Pattern	Unassimilated	Assimilated
{l,h,w}+yaFoMuLu	yalohuwu	yalohw
{r,m,y}+yaFoMiLu	yaromyiu	yaromy
{q,w,l}+yaFoMuLu	yaqowulu	yaqwlu
{b,y,d}+yaFoMiLu	yaboyidu	yabydu
{q,w,m}+>aFoMaLa	>aqowama	>aqAma
{m,y,l}+>aFoMaLa	>amyala	>amAla

Similarly, consonants (e.g., h, d, >, t, T, and m) may affect neighboring sounds so drastically that neither root nor pattern is easily extractable. Table 4 shows how assimilation affects roots with some of these consonants in the morphological pattern AiFotaMaLa.

Also glottals in sequence assimilate to adjacent sounds. If two glottal stops are separated by a short vowel, the second becomes a long vowel similar to the short vowel preceding it.

TABLE 4. CONSONANTAL ALTERATIONS

Root	Unassimilated	Assimilated	Change
{w,q,d}	Aiwotaqada	Ait-aqada	w->t~
{y,b,s}	Aiyotabasa	Ait-abasa	y->t~
{S,d,m}	AiSotadama	AiSoTadama	t->T
{D,l,E}	AiDotalaEa	AiDoTalaEa	t->T
{T,r,d}	AiTotarada	AiT-arada	t->T~
{z,h,r}	Aizotahara	Aizodahara	t->d
{d,x,l}	Aidotaxala	Aid-xala	t->d
{Z,l,m}	AiZotalama	AiTalama	Z,t->T
{*,k,r}	Ai*otakara	Aid-akara	*,t->d~
{>,z,r}	Ai>otazara	Ait-zara	>,t->t~

3.2 Metathesis

Metathesis is when root radicals in a word swap positions. Although this phenomenon is infrequent, it is nonetheless legal. Automatic root extraction tools often fail in this scenario because even for a human it is difficult to know that *nA'* 'to relate to being distant' came from the root {n,'y}. Another example is the root {r,'y} 'to relate to seeing' combined with the metathesized morphological pattern *FaLaMa* -> *raya'* -> *rA'a*.

3.3 Orthographic Transformation

Traditional morphology does not recognize orthographic transformation. However, in software, different character codes are assigned to different forms of the same letters. Unicode and other encodings of Arabic assign different codes to each form of the glottal. There are six standard forms shown in Table 5 with their Unicode values. Also the vowel 'aa' takes two different forms: A (\u0627) and Y (\u0649).

Morphological systems should be capable of recognizing different forms of the alphabet as well as the effects of morphological processes on orthography. Different forms of the glottal stop in Table 6 demonstrate the legitimacy of such distinction.

TABLE 5. GLOTTAL FORMS WITH THEIR UNICODE VALUES.

Citation Form	Buckwalter Symbols	Unicode
ء	'	\u0621
ا	|	\u0622
إ	>	\u0623
آ	&	\u0624
أ	<	\u0625
ؤ	}	\u0626

TABLE 6. ORTHOGRAPHIC TRANSFORMATION.

Root+Pattern	Realized As	Orthographic Change
{',m,r}+FaMaLa	>mara	' became >
{b,'s}+FaMuLa	ba&usa	' became &
{b,*'}+FaMiLa	ba*}a	' became }
{s,'l}+FAMaLa	sA'ala	' became '
{s,E,y}+>aFoMaLa	>asoEY	y became Y
{s,E,y}+>aFoMaLahu	>asoEAhu	y became A
{b,d,w}+FaMaLa	badA	w became A

3.4 Gemination Of Radicals

Gemination is problematic for morphological systems because when two identical consonants occur in a sequence of two open syllables in non-word initial position not followed by a geminate consonant, the second consonant is replaced with a geminate diacritic. In word initial position, they may either geminate or be left unchanged. Verb conjugation requires a verb to appear in both geminated and ungeminated form. As an example, the root {m,d,d} molded into the pattern *FaMaLa* produces *madada* but then surfaces as *mad-a* due to gemination. However, if this is affixed with the feminine pronoun marker *+ona* it surfaces as *madadona*. Successful morphological systems must be able to decide when separation of the geminate is required and when it is not.

3.5 Morphosyntactic Alteration

Arabic verb structure is affected by tense, voice, mode, and conjugation with the various subject and object pronominals, and clitics. Morphological systems must be able to recognize all these variations. The alterations can range from minor to major but have the most dramatic effect on imperfect and passive forms of verbs. Subject pronominal affixation also induces major alterations.

The past tense of all-consonantal trilateral and quadrilateral sound stems ending in radicals other than *t* and *n* are not changed much by morphosyntactics.

Verbs in present tense form use subjects different from those used by the past tense; they are made up of both prefix and suffix components. Both the start and end of a stem undergo morphophonemic transformation, introducing more alteration.

Morphophonemic transformations affect roots that do end in *t* and *n*, but the pronouns themselves and how they attach to stems both past and present remains the same.

Roots with a glottal stop radical in the initial and medial positions are usually modified further by orthographic rules when affixed.

Triliteral geminate stems in the past tense require simple agglutination of vowel-initial subject pronominal suffixes and the reversal of gemination for consonantal pronominal suffixes. Similarly, for present tense stems, gemination is broken before attaching a consonantal-initial prefix component but otherwise left unaltered.

Past tense stems of semi-vowelled roots behave similarly to stems of all-consonantal roots when affixed for person. In the same way, present tense, *y*-initial stems (e.g., *yaqaZ*) behave like all-consonantal when the prefix component is pre-pended. On the other hand, present tense stems of *w*-initial roots behave very differently as the initial *w* is dropped entirely. For example the past tense stems *waqaf* and *kasar* behave similarly when affixed with the feminine second person singular subject *+at* creating the forms *waqafat* and *kasarat*. However, the present tense forms following the affixation pattern for the same pronoun *ta+stem+u* results in *taqifu* and *takosiru*. One can see that the initial radical of the first stem completely disappears, unlike the first letter in the second stem that remains.

Semi-vowel stems in medial position are even more problematic and the transformations they undergo are extremely complex. Not only does the affixation process have to be mindful of the suffix syllable structure but also of the stem's last syllable and medial syllable structures. It has to still perform the usual prefixation processes for the present tense. This means, in effect, that every part of the stem plays a role in subject pronominal affixation.

The same rules of adding subject pronominal affixes to stems of all-consonantal roots apply to stems of medial semi-vowelled roots. The difference, though, is that the medial radical is substituted for a short vowel of similar quality (i.e., *i*), or a long vowel of a different quality (i.e., *A*), or sometimes it retains the radical.

Stems ending in semi-vowels are also challenging for computational morphology. Sometimes these semi-vowels convert to pure vowels, but in other conjugations the vowels turn back into the original root radical which in the stem may have surfaced as a different short-vowel. Take for instance the stem *baliy* 'to put to the challenge': if its imperative form is attributed to the second person masculine singular the semi-vowel is deleted (i.e., *Aibola*), but remains unaffected in the second person feminine singular, feminine plural, and dual subject pronouns (*Aibolay*, *Abolayon*, *AibolayA*). When the third person masculine plural is used the semi-vowel is replaced (*AibolwA*).

Further morphophonemic transformations affect derivative words in the present tense with the last radical converted to a vowel, its semivowel origin, deleted altogether without modifi-

cation of the preceding syllable, or deleted with vowel insertion in the preceding syllable.

Stems with two semi-vowel radicals have more complex affixation.

Additionally, associating object pronouns with stems and agglutinating other clitics adds even further alteration. Although most of these modifications are usually agglutinating, the importance of recognizing them should not be overlooked. Failure to recognize clitics and object pronouns may lead some algorithms to confuse clitics with stems.

Clearly, affixation and cliticization are a formidable challenge to morphology systems. Any morphological system that hopes to succeed must address and handle these issues with care and should successfully analyze or generate stems that have been transformed by all the processes discussed here.

4 THE PROPOSED GOLD STANDARDS LIST

4.1 Structure And Representation

The proposed list of test items we devised is 582 tokens covering 69 root types, 39 morphosemantic patterns, and 38 affixation induced contexts. Each combination is represented by one token that was selected from Al-Waseet Dictionary at random by automatic means. The list also includes exemplifiers of some phonotactically possible roots and morphologically acceptable derivations.

4.2 Root Types

There is a full representation of every root category that the language is considered to possess. The root types consist of the traditional root categories as well as several more we chose. Roots have been classified on the basis of the number, position, and value of root radical types. The idea is to pinpoint all the combinations of positions that transformation inductive root radicals may have. In traditional categories, the transformation inductive letters are the semi-vowels (*w*, *y*) and the glottal (*ʔ*). However, we added *t* and *n* to the list of transformation inductive letters, because their position in root-final position causes morphological alteration when combined with subject pronominal suffixes.

The proposed list contains a representation of numerous root types that are acknowledged in classical morphology but are never given an independent class. For example, the glottal stop and semi-vowel inclusive roots have always been recognized as distinctive and have called for separate root categories. However, roots that contain both a semi-vowel and a glottal have not been assigned an independent category although they undergo the morphological and orthographic transformations that are typical of both semi-vowel and glottal inclusive roots.

We also include exemplifiers of defective verbs. This category is non-derivational by definition; however, several of its verbs take multiple forms and undergo alterations much the same way as do other verbs. For example, the word *layosa* 'not' behaves as a negative particle and cannot be conjugated for tense, mode, or voice. However, it may take affixes in the same way that a non-defective verb does.

Every root class is represented in our proposed list. The number of tokens for each root type is determined by its pro-

ductivity (number of morphological patterns in standard use). Thus, the productive all-consonantal is represented by 42 tokens of actual dictionary entries, whilst glottal-initial roots are represented by only 14 tokens. All-consonantal roots utilize 33 different morphological patterns, and some of these are realized in multiple forms. To be truly representative of the variations that verbs may undergo, we needed to take one exemplifier per root-pattern combination. On the other hand, glottal-initial roots only use 14 morphological patterns, so they needed less exemplifiers of this category.

4.3 Root Lexicon

To test the ability of computational systems to detect words made of invalid roots, the list includes eight tokens of phonotactically valid verbs of all-consonantal trilateral roots, the most common verb root type. Each token gives an example of one of the most productive morphological patterns. Similarly, two more phonotactically valid but non-existent roots of four all-consonantal radicals are represented using two different morphological patterns.

4.4 Morphological Patterns

Traditional morphology recognizes 35 verbal morphosemantic patterns [13]. The proposed list covers 39 such patterns recognizing popular usage in Modern Standard Arabic and taking into account defective verbs [14]. For example, the pattern *maFoMaLa* 'to apply one thing to another' is commonly used in modern technical writing. So, for instance, the following words appear frequently in modern texts: *maEojana* 'plastered, applied paste', *masoraHa* 'staged, applied to the theater', and *manoTaqa* 'ratiocinated, applied rational thinking'. Other new patterns are those that model defective verbs which are neglected by classical morphology, e.g., [15]. These patterns are *FiMoLa* and *FaMoLa* because they behave in affixation similarly to patterns of non-defective verbs. Morphological systems will encounter such words and need to be able to deal with them correctly.

Morphosemantic pattern variants are also represented whenever a pattern is realized in more than one form. Six such patterns have two variants each, whilst all others have only one.

4.5 Morphological Processes

Representative tokens have been included of words that have undergone all the morphological and orthographic phenomena discussed in the previous sections.

4.6 Clitics

Clitics are also completely represented in the proposed list. There are two major categories: those that agglutinate to past tense verbs and those that agglutinate to the imperfect (present and imperative). Represented also are correlative conjoins made up of parts that attach to both ends of a verb.

5 FUTURE WORK

We have proposed here test data consisting of a list of word-root pairs that we claim to be thoroughly representative of Arabic verb morphology. We hope that either we or others would

take up the challenge of preparing a data set that would extensively represent Arabic noun morphology. Furthermore, we hope that this work would spark a fruitful discussion amongst computational morphologists on what constitutes gold standards for their field. The current proposed Gold Standard list may be retrieved from the authors' homepage³.

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A Hands-on Approach to Capstone Design and Implementation

Joseph T. Catanio
LaSalle University
Mathematics and Computer Science
Department
Philadelphia, PA 19141
1.215.951.1142
catanio@lasalle.edu

Abstract - Students planning to work in the software industry are best served by exposure to the type of skills necessary to acquire employment in a software developer capacity. One way to prepare students is to teach students the software development life-cycle process utilizing a design and implementation two-course capstone project. This paper describes a successful teaching approach to the capstone project by utilizing a practical hands-on approach.

I. INTRODUCTION

Can the phases of the software development life-cycle effectively be taught to students utilizing a practical hands-on approach? The software community expects students to possess a firm understanding of the software development process and have criticized computer science (CS) and information technology (IT) education for the lack of focus on business values and critical thinking [10]. The National Research Council [4] reports that by providing students with the necessary skill sets prior to entering the workforce to be more effective when transitioning from academia into the software industry workplace. One of the key points mentioned in the report is that too much attention is placed on theoretical topics and not enough emphasize is placed on practical application.

To place more emphasize on practical application, it seems prudent to provide students a hands-on approach in developing software projects similar to the way software is developed and maintained in the software industry. To this end, the author has incorporated a structured methodology utilizing various techniques into a senior level undergraduate capstone two-course combination. This approach should help reduce the school-to-work gap [6] and afford students a better opportunity in securing employment. Mann [9] refers to this as the IT-User gap and points out that academic curriculums and business practices are often disconnected and do not provide students with the necessary skill sets to satisfy industry needs and expectations. The following paper describes an effective teaching approach utilized to help students prepare for the workforce by

developing a capstone project in an agile development approach.

II. CAPSTONE PROJECT OVERVIEW

LaSalle University provides its seniors a two-course sequence of courses with the intent that these two courses will act as a capstone on the undergraduate experience. To do this, students develop a mid-to-large size semi-realistic project utilizing the six phases of the software development life-cycle, namely requirements elicitation, analysis, design, implementation, system test, and operations and maintenance. Although ad hoc processes are often used in the software industry, the capstone project uses a more structured approach. Such an approach concurs with the research literature that systematic processes allow low experience individuals and groups the ability to achieve a similar level of quality as high experience individuals and groups [1][3], thereby leveling the playing field.

The first course is entitled Project Design and is offered during the fall semester. The intent of this course is to focus on requirements elicitation, analysis, and design phases of the software development life-cycle by developing a comprehensive software requirements specification (SRS). The second course is entitled Project Implementation and is offered in the spring semester. The intent of this course is to focus on implementation, system test, and operations and maintenance phases of the software development life-cycle by utilizing the previously created SRS as a baseline.

Objectives

At the start of the capstone project, the instructor outlines and explains the objectives, deliverables, and expectations of the two semester capstone project to the students. To help facilitate the initial meeting, both Project Design and Project Implementation courses are explained using the following bullet items categorized into conceptual understanding and application experience themes:

Project Design Conceptual Understanding

- Processes involved in requirements engineering.
- Aspects of project management, including tracking progress.
- Process of determining system and software requirements.
- Importance of good analysis and design.
- Various structured analysis and design (SAD) and object-oriented analysis and design (OOA) techniques.
- Design principles for current interface technologies.
- Design principles for data modeling.
- Architectural considerations.

Project Design Application Experience

- Working in a significant team development project.
- Managing a significant project.
- Conducting interviews as part of requirements determination.
- Using SAD and OOA analysis and design methodologies.
- Performing system and interface design.
- Constructing an appropriate database model.
- Deciding on system platform configurations.

Project Implementation Conceptual Understanding

- Processes involved in implementing a software system from a software requirements specification (SRS).
- Concepts and strategies behind system verification and validation and quality management.
- Aspects of change management, including configuration management and problem tracking.
- Aspects of project management including managing people.
- Issues involved with maintaining and evolving legacy systems.

Project Implementation Application Experience

- Working in a significant team development project.
- Managing a significant project.
- Carrying out implementation in an iterative fashion.
- Appreciation for and experience with project design concepts.
- Implementing a software system.
- Maintaining a software system.
- Configuring the hardware platform.
- Installing a software system.

The objectives are based on the fact that the capstone project focuses on the integration of knowledge rather than on coverage of new academic content or development of new skill sets [5]. One of its purposes is to develop a

realistic project based on synthesizing previous course work [8], such as multi-tier platform architecture, network security, algorithm design, coding, database design, and software testing. Fundamentally, the overall goal is for all students to develop, from the ground-up, a software system with corresponding documentation in which they can be proud!

Team and Project Selection

The capstone project is a team project and students are permitted to create their own teams and work in groups up to three based on project scope. Software development is generally a team effort and one goal is to recreate an academic project environment similar to a way software is developed and deployed in the software industry. A team approach provides students the opportunity to acquire and/or improve non-technical team-oriented skills [2] especially in the area of communication, working together, and project management.

Teams submit a general proposal of a system they plan to develop for their capstone project. The proposal is based on developing a system to align with an organization's business objectives. Experience has shown that students generally are more committed to a project if they themselves propose the idea, which has helped to alleviate many problems with capstone courses identified in Green [8]. The instructor reviews all proposals and provides a go/no-go decision. Typically all proposals are accepted with instructor provided modifications based on project scope and team size.

III. DEVELOPMENT ENVIRONMENT

All projects are to be specified and implemented based on three-tier client/server architectures utilizing Intel-based servers and desktop computers and Microsoft software development toolkits. The backend or database layer utilizes Microsoft SQL Server. The middle-tier and presentation layers utilize Microsoft Visual Studio.NET framework. Prior to implementation, an SRS is generated utilizing Microsoft Office programs, such as Word and Visio.

IV. DELIVERABLES BASED ON MILESTONES

The milestones and deliverables are tightly coupled with the phases of the software development life-cycle, implemented in an agile manner. Prior to actual prototype development, the Project Design course teaches various techniques of requirements elicitation, analysis and design, and architectural considerations that are incorporated into an initial project proposal as well as final specifications. Both IT and CS students benefit from these steps because students improve their problem solving skills. An important aspect is to understand how the proposed system benefits the organization by aligning with the strategic goals of that

organization as stated in the proposals. Thereby a student's proposed system does not exist in isolation; instead it is an integral component of the organization, thereby bringing to light business needs and not just technical needs, which are often identified as major problems with capstone courses [8].

Milestone 1: System Identification

Many students are actively involved in university clubs and organizations, while others are active in the business community. The capstone courses leverages this experience by encouraging students to evaluate a known organization and propose a system that will add value to that organization. Therefore, the first milestone is threefold, namely to find a project sponsor within an organization, identify a needed system, and scope out basic requirements. The approach taken is to narrow the scope of the project by identifying the preliminary systems requirements and architectural considerations. In addition, system stakeholders are also identified and their relationship to the project documented. Stakeholders have different agendas and perspectives of what the system is to deliver. To get the system "right" and increase the chances of system acceptance, all perspectives must be considered. To this end use-cases and scenarios are developed to help identify system functionality. Students are reminded that this is an iterative process and an evolving document. As subsequent steps are performed, additional requirements general surface and must be incorporated into the design and the SRS document iteratively.

Milestone 2: System Modeling

Once the basic functionality is identified, data and process modeling techniques are demonstrated and incorporated into each group's specific project. The proposed systems are decomposed utilizing a collection of data flow diagrams and various flow charting techniques. This is generally a difficult step because many students, as well as software professionals, tend to jump directly to the coding aspects of system development, which is not the best approach because basic system functionality has not yet been identified nor the way to present the features to the user. Students need to first focus on the "what" before the "how." [7]

Milestone 3: Graphical User Interface

Third, screen shot layout or graphical user interface (GUI) design is performed. Rapid application development (RAD) tools are utilized to provide the first prototype based only on system look and feel. The first prototype depicts system flow without functionality. All stakeholders use the first prototype as a common point of reference to the proposed software system. This is a visual tool that permits a more effective manner to explain proposed system functionality as well as additional software requirements. To provide a realistic environment, each project team will present their GUI prototype in a presentation business meeting format

with all stakeholders present. During the presentations, each project team will be asked to add new functionality to the proposed software system that must be incorporated into the SRS as well as subsequent prototypes. All changes are to be incorporated into the second prototype, which is then presented in a business meeting format as before. Provided all original and new requirements are met, all stakeholders must sign-off on the design, thereby solidifying project scope.

Milestone 4: Database

As the GUI prototypes are refined, database modeling begins to lay out the database table structure of the system. Also, hardware and software system architecture configurations are identified and incorporated into the SRS. Each team member is to understand and actively participate in each phase thereby leading to an effective and efficient team dynamic.

Once system functionality agreement is reached among all stakeholders and database tables are designed, plans and procedures are developed to install and maintain the proposed system in the target environment in an incremental fashion. The approach is to setup two identical systems, namely the development/test and production systems. This allows students to learn first-hand the importance of creating and following procedures to install, upgrade, and maintain system software application programs. Project kinks are to be resolved using the development/test systems before modifications are made on the production systems. If handled correctly the modifications to the production systems are incorporated seamlessly, thereby requiring minimal downtime and lower risk of disaster.

Milestone 5: Final System Proposal Meeting

A third business meeting is held at the end of the semester for all teams to present their project designs to all stakeholders. At this point, all teams have an excellent understanding as to what must be implemented by having a comprehensive SRS as well as a screen-shot GUI prototype. A final sign-off sheet is utilized to help reach consensus as to the system requirements and becomes part of the system documentation.

In addition, all students individually submit a lessons-learned report on their experiences, both good and bad, concerning the first-part of the capstone project. The intent is to utilize the information to improve the course. The report also acts as a reflection paper for each student to examine and discuss their contributions to the project as well as their individual experiences working in a team environment to develop an SRS.

Milestone 6: System Prototype 1

Coding, testing, installation, configuration and maintenance begin in the spring semester as part of the Project

Implementation teaching concepts. Students are taught how to develop and deliver a networked three-tier system utilizing an object-oriented approach. The back-end layer implements the database using the Microsoft SQL Server database management system (DBMS). In addition to the creation of the database tables, all read/write access to these tables is realized through stored procedures. The middle-tier involves the creation of class libraries implemented as dynamic link libraries (DLL). These DLLs implement the business rules of the system and demonstrate code reuse and parameter marshalling. The presentation layer focuses on GUI concepts and presenting an easy to use interface to the user, while invoking methods contained within DLLs.

The first prototype involves setting up the software system on the target hardware platform. Each team of students installs, configures, and secures the database on the DBMS on a server system. Test plans and programs are developed to verify proper installation and that proper network authorization is in place to access the DBMS. The test plans become part of the system documentation. Concurrently, the GUI prototype is implemented as an executable application program on one or more client machines. At this point, the GUI does not interface with the backend database, but provides the framework to the look and feel of the system. Problems encountered are recorded in bug reports and become part of the system's documentation for tracking purposes.

The first prototype is presented to the class and instructor in an informal manner. The primary goal is for each team to properly configure the necessary hardware and software components in a networked environment. Each successive prototype provides more functionality until all system operations are implemented.

Milestone 7: System Prototype 2

With the base system in place, each team begins to add functionality to the system by adding methods to the DLLs, which in turn are invoked from the GUI based on user interaction. The target is to complete approximately half of the required system functionality and fold it into the second prototype. Teams are responsible to coordinate the needed activities to install new components, upgrade existing components, and upgrade existing application programs on development/test and production machines.

As in the fall semester, to provide a realistic environment, each project team will present their second prototype in a presentation business meeting format with all stakeholders present. This is primarily an informative meeting to keep all stakeholders on the same page and fully aware of the progress.

Milestone 8: Final System Prototype

A final business meeting is held at the end of the semester for all teams to present their fully functional systems to all stakeholders. The students have the opportunity to show-off their hard work and fine tune their presentation skills. Any outstanding bugs and a plan to fix those bugs must also be presented. In addition, any functionality contained within the SRS but not provided in the final prototype must also be presented as well as an implementation plan to incorporate the missing functionality.

Finally, all students individually submit a lessons-learned report on their experiences, both good and bad, concerning the second-part of the capstone project. The intent is to utilize the information to improve the course. The report also acts as a reflection paper for each student to examine and discuss their contributions to the project as well as their individual experiences working in a team environment to program, test, install, configure and maintain a system.

V. EVALUATION

Evaluation is based on the milestones, which are measured based on the design models and system prototypes delivered. The Project Design course utilizes five separate checkpoints, namely:

- Initial problem and requirements statement
- Data and process models
- Database model
- GUI design
- Final SRS

The Project Implementation course utilizes three evaluation checkpoints, namely:

- Prototype 1
- Prototype 2
- Final System

VI. FUTURE RESEARCH

To help measure the success of the capstone courses the author plans to develop instruments to measure the usefulness of the capstone courses from student and employer perspectives. Since the capstone courses are designed to provide students with the necessary skill-sets prior to entering the workforce, measurement instruments are essential to ascertain effectiveness. The author is currently making contacts with employers of recently hired graduates whom having completed the capstone courses. Working together with the software business community will help refine the capstones courses and reduce the school-to-work gap, thereby helping to align academic curriculums and business practices.

VII. SUMMARY

This paper presents a practical hands-on approach to the capstone project. The capstone is a two-semester series of

courses that teaches the software development life-cycle to students utilizing the design and implementation of a software project in a team environment. Students learn the importance of design prior to its implementation.

The capstone courses mimic the development of software in an agile manner and divide the project deliverables into milestones, which are presented to all stakeholders in a series of meetings throughout the project development life-cycle.

The fundamental goal is to provide students the necessary skill-sets needed prior to entering the workforce. This approach helps to reduce the school-to-work gap and is effective when transitioning from academia into the software community workplace.

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E-Learning in Technology – Using Project Merlot as a Resource

Dr. Judy A. Serwatka
Professor of Computer and Information Technology
Purdue University North Central
1401 S. US 421
Westville, IN 46391
jserwatka@pnc.edu

I. Introduction

One of the greatest challenges to faculty who design and implement distance learning courses is finding good teaching material in an on-line format for their classes. Simply putting the same material that was used in an on-campus class on a web site and expecting the on-line students to learn at the same level as their on-campus counterparts is not logical. Distance learning requires a new pedagogy and alternative teaching tools to enable the learner to grasp material without the benefit of an instructor's lecture.

Searching the Web for appropriate teaching materials and on-line simulations can be time-consuming and frustrating. The sheer volume of Web sites is overwhelming and a search that returns thousands of potential Web sites for a particular subject is enough to discourage anyone from trying to find Web-based materials for courses.

Project MERLOT (**M**ultimedia **E**ducational **R**esource for **L**earning and **O**nline **T**eaching) is an effort to try and minimize the number of Web sites searched and provide a way to find quality instructional materials in a minimum of time. As faculty, we can benefit from the materials already posted

on Project Merlot for our on-line courses.

II. Background and Purpose of Project MERLOT

Project MERLOT was initiated by faculty and administrators at several universities across the United States. The leaders for the project are located at California State University. The project was originally implemented by continuing an NSF project titled "Authoring Tools and An Educational Object Economy" at the Center for Distributed Learning (CDL) of California State University. Because of the interest generated by the initial project, the CDL invited other institutions and higher education systems to participate in order to expand MERLOT. The project is currently sponsored by the NSF Digital Library Project and endorsed by NLII/EDUCAUSE.

The purpose of Project Merlot is to develop a place where faculty can share instructional materials for all forms of on-line teaching. Material on the MERLOT Web site can be reviewed and downloaded by anyone, at no cost. Downloads are not limited to university faculty. This unlimited access provides

the opportunity for more faculty and instructors to become involved in on-line teaching without “reinventing the wheel” each time the same topic is taught. Of course, this means that contributors must agree to allow their material to be use by other faculty.

Currently, 15 disciplines are included in the MERLOT project including Biology, Business, Chemistry, Engineering, Health Sciences, History, Information Technology, Mathematics, Music, Physics, Psychology, Statistics, Teacher Education, Teaching and Technology, and World Languages. The sites listed in each discipline are reviewed and rated by a team of faculty reviewers for that discipline. The faculty who were chosen as reviewers have been identified as outstanding educators in their discipline and have demonstrated expertise in using the Internet as part of their courses. A contributor chooses which discipline under which to list the module.

The web site for Project MERLOT (www.merlot.org) encourages contributors to submit course modules on specific topics. For instance, an instructor teaching a course in Computer and Information Technology might submit a tutorial module on token-ring networks. Such a module could consist of lecture materials and a self-study quiz. A module submitted in Physics, currently on the site, illustrates the concept of Thermodynamic Equilibrium, using a Java Applet to show how gas particles move based on their temperature. Modules limited to a single topic are the most useful for the Project. Many different types of modules can be submitted, ranging from tutorials to simulations. Anything that an instructor would find useful is acceptable.

A problem that has surfaced with on-line courses is the perception that they are not of the same quality as traditional courses because there has been no peer review process in place for the materials. Faculty who teach in this format have found that their institutions require peer review of their materials for promotion and tenure. Project MERLOT provides such peer review of the materials posted on its Web site. Before reviewing modules, the faculty reviewers scan the lists of submitted modules and determine which ones are eligible for review. This process is known a ‘triage’ and the team in each curriculum does this on a regular basis to ensure that the site has only good materials. The Merlot system also has a mechanism for updating out-dated links. The original contributor is contacted when an old or bad link is discovered and is asked to either update the link or eliminate it from the database.

III. Review Process in Project MERLOT

Each discipline team is made up of a discipline Editor and several faculty reviewers (the author is the Editor of the Information Technology team, made up of 9 faculty). Before the review process started, the teams were given the task to find Web-based modules and post them on the MERLOT Web site under the appropriate discipline. Because of this, the faculty reviewers have become contributors as well as reviewers. When the project first began, it was important to populate the site with as many modules as possible. The current focus is to find high quality sites and then post them for review.

After a sufficient number of modules have been identified and

posted, the team members choose the sites they wish to review. In Information Technology, we divided our team into sub-teams, since there are so many different areas of expertise (programming, databases, networking, etc.). Each team then chooses sites from the MERLOT site to review. An important aspect of the review process is the use of a single review form by all members of a review team. Project Merlot has developed an on-line review form that each discipline team now uses to ensure that the reviews are equivalent.

The formal review process consists of informal reviews by individual team members, sharing the review forms among the team members, then a walk-through of the site with all members involved in analyzing the merits and problems with a particular site. Prior to the formal review, a letter is sent to the author of the module, indicating that the site has been posted to MERLOT and asking permission to review the site and post the reviews for all faculty to see. If the author denies permission, then the review process ends, and the site will remain on MERLOT with no posted reviews. If the author agrees to the review, the final review is posted on the MERLOT web site, with a 1 to 5 star rating, similar to that used by the motion picture rating system. The author is also sent a letter that contains comments by the reviewers along with suggestions for improvement of the module, if needed. We have found that authors sometimes request that the reviewers postpone their review of a particular module until a later date because the site is undergoing upgrades. If this occurs then we respect the author's request and delay the review.

The review process provides benefits to faculty in several ways. The

author is provided with a peer review of the material by faculty from across several universities. The perspectives and teaching experiences of several people are incorporated into the review, giving it a better review than could be done by an individual reviewer. Evaluating a course module in this manner is very valuable. As accrediting bodies take a close look at distance learning programs and individual courses, obtaining peer review of the teaching materials will be an important benefit to those developing the materials. In addition, the promotion and tenure process often requires that non-tenured faculty provide evidence of teaching effectiveness and this process often requires peer review of teaching materials. The MERLOT review process and the letters sent to the author can provide evidence of such a review.

Another benefit to faculty of the MERLOT review process is the public posting of the reviews. By browsing the MERLOT Web site, an instructor can find materials for specific topics. When someone searches the site for a specific item, modules that meet the criteria are listed with the highest ratings first, giving the searcher the benefit of finding the highest quality modules very quickly. The reviews can provide an efficient way to determine if the materials are appropriate for a specific class or a specific group of students. The rating system also provides a quick review of the quality of the material in the module. Comments by reviewers are included in the posted review as well.

IV. Example of Merlot Use

Let's say that I'm looking for a good, interactive activity for my Computer and Information Technology students,

whether they are on-line or on-campus. I go to www.merlot.org, click on 'Science and Technology' on the left of the screen, click on Information Technology and choose a topic. Or go to the Information Technology portal and choose my topic from the list. I generally teach networking classes, so I would click on networking, noting that there are 146 entries in this category. The system defaults to listing the sites by 'rating', meaning that the highest rated site(s) is/are listed first. But, you can change that so that you get a listing by title, author, etc. Another feature of the site is that each site that is listed is described with the type of activity (such as tutorial, animation, quiz, etc.). For my class, I'm going to choose the OSI Model Quiz. I can click on the link for the actual site, a new window opens (linking to the actual Web site for the quiz, outside the Merlot site), and now I can copy that URL and use this for my class. Or, I can stay on the Merlot site, click on the name of the site and then view the reviews and comments that have been completed on this site.

The same procedure can be used for whatever discipline is required. The site is very easy to use, and the portals for each discipline provide additional information for faculty. Since this site is designed for and used by faculty, it specifically targets that group and provides all the information needed to match faculty to their teaching needs.

The site has seen good usage over the years. The following statistics have been taken from the Merlot Web site in October, 2006:

Materials	15086
Members	39049
Peer Reviews	2093
Assignments	1025

V. Future of MERLOT

The success of MERLOT depends both on the willingness of faculty to spend the time to review the modules, and the time taken by those who seek out and post modules to the site for review. Anyone can post a module on the site. Reviews can only be posted, however, by those who are designated as faculty reviewers. MERLOT is not a repository for the actual modules, but instead is a database of URLs with links to the actual modules. Thus, if a module changes, the MERLOT web site does not need to be changed. This keeps control of the module in the hands of the author.

The ultimate goal of this project is to hand over review of modules to professional organizations in the various discipline areas. The faculty chosen as reviewers have made a two year commitment to this process, so a permanent solution to the review process is needed. Since professional organizations are made up of faculty who are interested in the educational needs of their disciplines, it is logical that they should take over this review process. One way to achieve this is to introduce the organizations to the concept of Project MERLOT as often as possible. The discipline team members are encouraged to write about and make presentations at their institutions, professional conferences and other venues to introduce Project Merlot to as many faculty as possible.

In order to further the discussions about peer review of the online materials, the First International MERLOT Conference was held in August 2001 and was open to anyone interested in this topic. The conference, titled "Faculty Approaches to Instructional Technology: Content,

Collaboration, and Community" was designed for those interested in learning about shared content, peer reviews, learning objects, standards, and online communities. The conference was a good way for all reviewers and others to come together to discuss issues relating to the peer review of on-line teaching materials.

In subsequent years, the Merlot International Conference (MIC) has been held in various cities and has attracted many faculty and administrators who are interested in this project. Awards are given out for outstanding Web sites, as selected by the individual Editorial Boards. In addition, those who have made outstanding contributions to the Merlot project are also recognized at the conferences.

VI. Conclusion

Project MERLOT is a concept that is desperately needed in the world of distance learning. Anyone who has faced the possibility of developing an on-line course from scratch will appreciate the help that such a Web site provides. The support the faculty members receive from their individual institutions in this project will determine the ultimate success or failure of the project.

One problem that has been identified is the additional work that this has put on the faculty reviewers. One reviewer indicated that she had been given what she called "virtual release time" to work on the project. Even though on paper she had a release for Project MERLOT, in fact she had been asked to teach an extra class during the same semester so the release time was really non-existent. Support for this project is needed in order to have quality

reviews. The only way this will happen is if the faculty involved in the project have time to work on it. Those who are involved in this project are dedicated to improving the materials available for distance learning instructors. The importance of this form of teaching is evident in the number of commercial ventures that have been developed. The success of MERLOT will be measured by how well it helps faculty develop and improve their distance learning courses.

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On the Relation between Semantic Network and Association Map for the Assessment of Class Work

Kagehiro ITOYAMA*, Teruo NITTA** and Takashi FUJIKI*

*Faculty of Education, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521 Japan.

**Lifelong Learning Center of Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, 852-8521 Japan.

ABSTRACT- Authors had reported a paper [1] that two association methods were useful for the assessment of class work. Especially, association map was very useful to know the changes of schema of learners before and after class work. However, the association map does not express the flow that learners get the concepts in the class work.

In this paper, authors propose the new semantic network which is constructed from short contexts obtained from the stimulating word (*SW*) and the response words (*R*) in association test. Authors classify five patterns for short contexts and present the semantic network before and after class work.

Authors discuss on the effectiveness of this semantic network as a detailed document for the assessment of class work.

Key Words: Assessment of Class, Association Test, Semantic Network

I. INTRODUCTION

K. Itoyama et al. had reported a paper on the assessment of class work by using Association Method and had presented that it was very useful to assess the class work [1]. In the previous paper, we define the class work study as follows; Class work is the communicating field on which teachers inform to students "Learning Concept" through "Learning Material" by using the reasonable "Instruction for Study" in the "Environment for Study". In this definition, we can assess on the class work for mass group. However, we cannot know the process of getting knowledge and concept from the Association Method.

The response words recalled from the single stimulating word correspond to the schema of human beings [1], [2]. The schema is defined to be a prototype of concept [3]. And a situation of concept can be expressed by a semantic network

[4]. It is very useful to know the conceptual situation for getting concepts that this semantic network obtained from the contexts expresses the concept which human beings get.

Authors have been researching the semantic network for the assessment of class work from the contexts between the stimulating word (*SW*) and response words (*R*) in Association Test. In this paper, we discuss on the relation between the semantic network and Association Map and discuss on the learning process of learners.

II. RESEARCHING PROCEDURE

2-1. Contents of Class Work

An investigation object is 26 pupils of the third grade in F-junior high school in Nagasaki city. The contents of class are as follows;

- (1)The learning concept was a "transformation of metal" in concerning with "metal working" of technical and homemaking course in junior high school.
- (2)The learning materials were "wire" and "solder".
- (3)The instruction for teaching was a class by a discovery learning and group guidance.

2-2. Investigation Condition

The association test assumed stimulating words, which were "transformation" "wire" "solder" in learning before and after. The example of testing paper is shown in Fig.1. As shown in Fig.1, we had students fill out the short contexts by using the stimulating word and the response word within from 1 minute to 1 minute 30 seconds to make a figure of semantic network about each response word after the free association test for 30 seconds each.

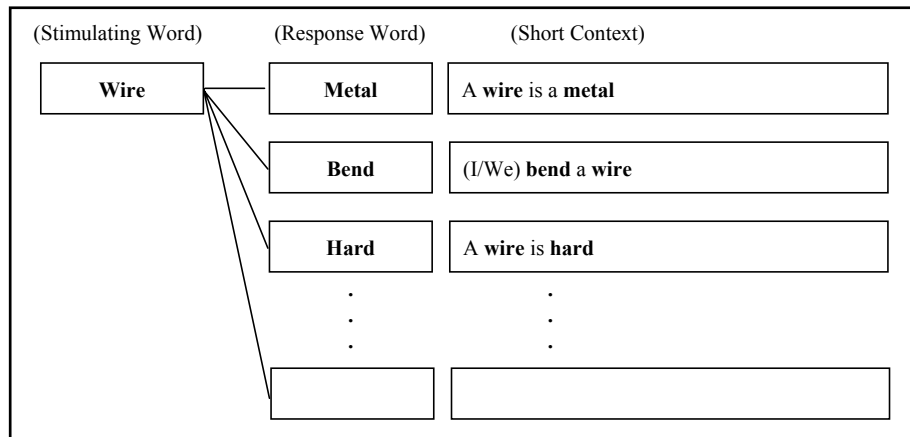


Fig.1 The example of testing paper of association test.

III. RESULTS AND DISCUSSION

3-1. Results of Association Test

(A) Before Class Work

Authors have been representing the changes of schema by the association map for the assessment of class work [1].

The association map before class work is shown in Fig.2. In this case, the stimulating word is “Transformation”. The most response word is “Clay” and the next one is “Metal”. And “Robot”, “Bend”, “Move”, “Rubber”, “Paper” and so on follow the above words. From these response words, almost of all response words are based on the experience of which learners had undergone. However, there are few response words which are concerned with “Transformation of Metal”. The number of response word is 138 words and the kind of response word is 90 words. The association entropy is 6.158 (bit).

(B) After Class Work

The association map after class work is shown in Fig.3. The most response word is “Elasticity” and the next one is “Plasticity”. And “Bend”, “Lengthen”, “Ductility”, “Change”, “Metal”, “Malleability”, “Solder” and so on follow the above words. All of these response words are concerned with “Transformation of Metal” which is the “Learning Concept” of the class work. The number of response words is 113 words and the kind of response words is 55 words. These values decrease after class work.

In comparison with association maps in Fig.2 and Fig.3, the knowledge and concept concerning with the “Learning Concept” appear in the association map after class work. This means that the association maps before-and after class work corresponds to the changes of schema.

3-2. Classification for Short Contexts

The association entropy is 5.319 (bit) and this value decrease after class work, too. In case of the discovery learning, the association entropy usually increases after class work. This means that the instruction of a “teach in” type was strong in the present class work.

It is very important to assess the class work and to know a cognitive process of human being, if we know a learning process of learner. So we had planned to make the semantic network between stimulating word (*SW*) and response word (*R*). We had instructed learners to make a short context by using stimulating word and response word as shown in Fig.1.

We learn basically drawing figures of a semantic network according to the thing which Rumelhart and Norman made [3]. Rumelhart et al. had proposed two contexts.

An arrow to tie up between concept names shows a type and directionality of relation of both. The relation that “*A* is *B*” or “*A* is a kind of *B*” expresses that *A* is a member of *B*, and this relation is shown by a curve from *A* to *B*. The relation that “*A* has a property of *C*” expresses that *C* is a subset of *A* and pulls an arrow by a straight line from *A* to *C*. Without two contexts mentioned above, we can find out the following contexts for the relation between the stimulating word and response word.

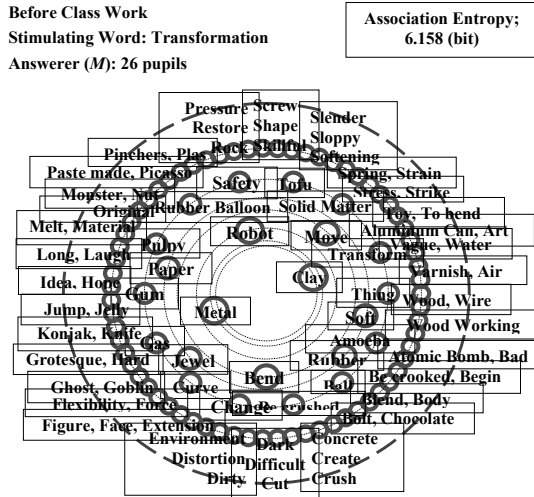


Fig.2 Association Map before class work; "Transformation of Metal" in Junior High School of Nagasaki City. Number of Response Word (N): 138 words Kind of Response Word (Z): 90 words Association Entropy (H): 6.158 (bit)

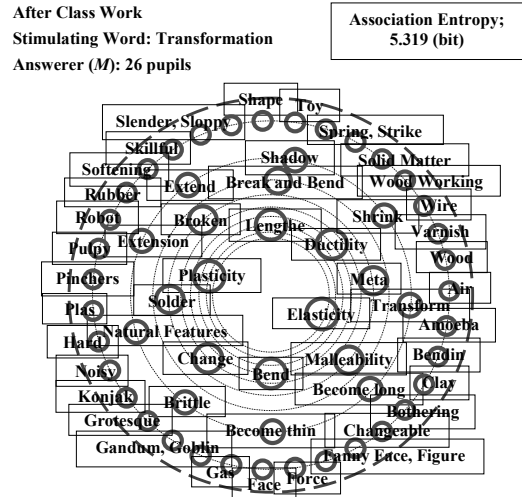


Fig.3 Association Map after class work; "Transformation of Metal" in Junior High School of Nagasaki City. Number of Response Word (N): 113 words Kind of Response Word (Z): 55 words Association Entropy (H): 5.319 (bit)

The contexts by using stimulating word (SW) and response word (R) can be classified several patterns. K. Itoyama et al. will propose the following contexts.

- (1) Member of B; A is B.
Example; A **wire** is a **metal**.
- (2) Similarity or Equality;
Both A and C are the (same/similar) (property/value).
Example; Both **wire** and **solder** are metal.
- (3) Subset of A; A has a (property/value) of D.
Example;
A **wire** is **hard**. A **solder** has the **plasticity**.
- (4) Cause and Effect; D is caused by E.
Example; A **wire** **lengthens** by **pulling**.
- (5) Prepositional Phrase;
(I/We) do act for A (preposition) F.
Example;
(I/We) bend a **wire** by **pinchers**.
(I/We) pull a wire with **my friend**.

In this classification (5), the objective word and the complement changes in accordance with change of preposition. In association the relation of the stimulating word (SW) and the response word (R) corresponds to the relation of the objective word and the complement.

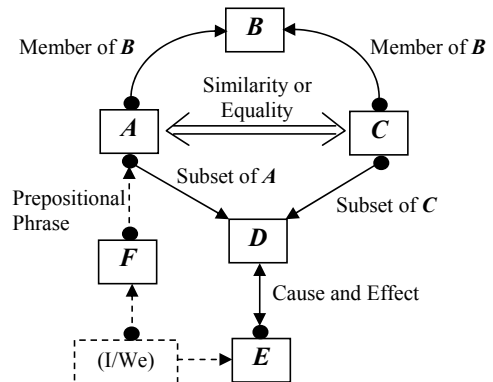


Fig.4 Basic semantic network by five kinds of contexts.

From contexts mentioned above, we have been presenting the semantic network totally as shown in Fig.4. An arrow to tie up between concept names shows a type and directionality of relation of both as shown in Fig.4.

3-3. Semantic Network for Class Work of "Transformation of Metal"

The semantic networks which correspond to the association maps before-and after class work are shown in Fig.5 and Fig.6. When we make these networks, we can find several sentences based on misunderstanding between the stimulating word (*SW*) and the response word (*R*). Namely, there are contexts based on misunderstanding concepts. We had made the semantic network without these contexts.

(A) Before Class Work of "Transformation of Metal"

Fig.5 shows the semantic network made by using contexts obtained from stimulating words "Wire", "Solder" and "Transformation". In this Fig.5, learners have got concepts which are that "Wire is a metal", "Wire bends", "To bend is a transformation", "A metal transforms" and so on before this class work.

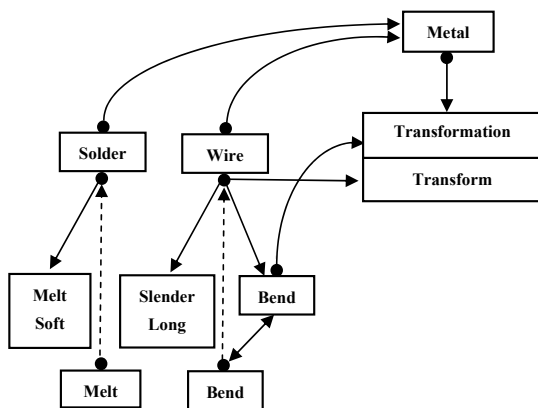


Fig.5 The semantic network before class work of "Transformation of Metal".

(B) After Class Work of "Transformation of Metal"

Fig.6 shows the semantic network after class work of "Transformation of Metal". In this Fig.6, the words, "Wire" and "Solder", of left side are the "Learning Material" and the word of the right side, "Transformation" is the "Learning Concept" of this class work. Further, the bottom part in Fig.6 shows the "Action" of learners in this class work. Namely, all of learners had bent, had beaten, had extended and had pulled the wire and the solder. And they had got the knowledge of "Elasticity" and "Plasticity" from results in cases that wire was restored or not, when the external force was removed. Moreover, many learners had had experience that wire and solder became thin and extended by beating and pulling. Many learners had represented following short contexts from these experiences;

- (I/We) bend a wire. So wire bend.
- (I/We) beat a solder. So solder becomes thin.
- (I/We) pull a wire. So wire lengthens.
- A wire has a property of the elasticity, when a wire is restored.
- A solder has a property of the plasticity, when a solder is not restored.
- A wire has a property of the malleability, when a wire becomes thin.
- A solder has a property of the ductility, when a solder lengthen.
- The elasticity is a transformation of metal.
- The plasticity is a transformation of metal.
- The malleability is a transformation of metal.
- The ductility is a transformation of metal.
- A metal transforms.

The semantic network in Fig.6 shows the structure of scientific concepts on "Transformation of Metal". Of course, teacher had concluded these concepts on the "transformation of metal" in the last stage of the class work.

As shown above mentioned short contexts, the relation of action by learners and the response words, "Bend", "Become thin", "Extend" and "Lengthen" are the "Cause and Effect". The discovery of the "Cause and Effect" has the very important meaning to acquire the concept in class work. Namely, the action by learners plays the very important role to get the concepts. This had reported by many researchers. But, we can hardly find papers which show the role of action by learners in the semantic network.

The semantic network as shown in Fig.6 shows the teaching process. And, by changing point of view, Fig.6 shows the learning process. Of course, Fig.6 is constructed by all learners who participate in this class and cannot be constructed by one learner.

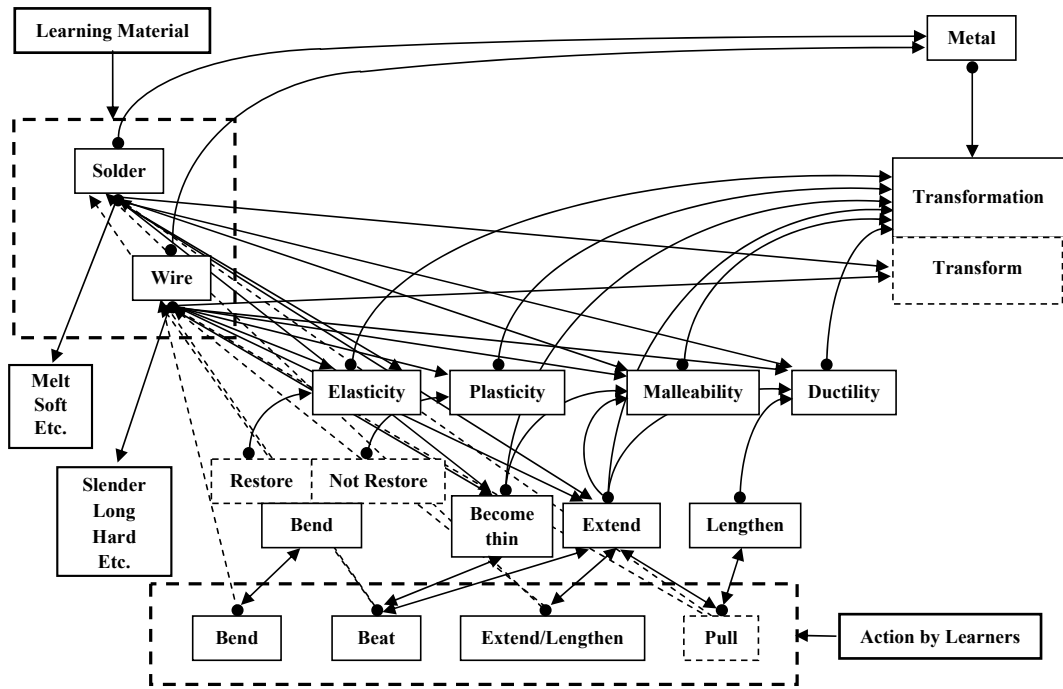


Fig.6 The semantic network after class work of “Transformation of Metal”.

The association entropy, which means the degree of disorder of response words, shows the almost same value, when the value of $(t \times M)$ is same. In here, t is the recalling time and M is the number of answerer. Therefore, the disorder of response words for the small number of answerer becomes to be as similar disorder as one's for the large number of answerer by extending the recalling time [5]. Even though just only three persons, they are enough too many by extending recalling time. Therefore, even though just only one learner, he will be able to find his way to this semantic network by extending thinking time.

The authors has judged that almost of learners had got some concepts, “Elasticity”, “Plasticity”, “Malleability”, “Ductility” and “Transformation of Metal” with retracing the directionality of the arrow as shown in Fig.6.

Generally speaking, the scene of action does not involve in the semantic network. In this work, the authors has proposed five classifications, which are “Member”, “Similarity or Equality”, “Subset”, “Cause and Effect” and “Prepositional Phrase”, from contexts obtained between the stimulating word

(SW) and response words (R) in association test. The present semantic network based on five classifications mentioned above can explain the process of learning (or teaching).

We are able to know the relation between response words that learners answered by expressing them by the association test of class before and after in a figure of semantic network. Therefore it is useful as a detailed document for the assessment of class work. The association map is effective to grasp the situation of concept acquisition of learners by association test for 30 seconds about a single word. Furthermore, the expression by the semantic network is of use when we give more detailed class assessment. An instructor to teach makes a figure of this semantic network before a class, and it is considered that effective class assessment is enabled in comparing with a response word by association test of class before and after.

However, we must discuss on classification more carefully by contexts obtained between the stimulating word and response words in association test. In association we can find other patterns, which are “Circumstances” and “Opposite Situation” except five classifications mentioned above.

The false contexts do not employ to construct the semantic network in this study. If we will make the semantic network with involving the false contexts, we can discuss on what learners are lead to the false concept. In this work, we cannot approach to this problem.

IV. CONCLUSION

The authors propose the new semantic network which is constructed by using short contexts related between the stimulating word (*SW*) and the response words (*R*) recalled by the association test. The authors classified by five patterns for the short contexts. And we propose the new semantic network basically as shown in Fig.4. As results,

- (1) The present semantic network based on five classifications can explain better the process of learning (or teaching).
- (2) The action by learners plays the very important role to get the concepts. The present semantic network can show the role of action by learners.
- (3) The present semantic network is useful as a detailed document for the assessment of class work. An instructor to teach makes a figure of this semantic network before a class, and it is considered that effective class assessment is enabled in comparing with the response words by association test of class before and after.

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TOWARDS A METHODOLOGY FOR ONTOLOGY DEVELOPMENT

Kornelia Todorova
Sofia University CIST
Tzarigradsko Shausse 125 bl.2 fl.3 Sofia 1113,
Bulgaria
E-mail: cornelia@fmi.uni-sofia.bg.

Abstract: Analysis of existing methodologies for ontology development is conducted and basic problems and drawbacks are defined. The goals of this article are to propose possible solutions for these identified problems by developing a specific approach and giving detailed guidelines for ontology creation. Proposed approach, summarizing best practices in the field of ontology development, is demonstrated by describing the process of implementation of specific ontology. The approach includes basic methods, rules and principles. Main results from the application of the approach are discussed and analysed.

I. INTRODUCTION

One of most important problems of modern e-learning is lack of clear and systematic methodology for description, development, sharing and exchange of learning resources. Ontologies seem to be an appropriate decision of this problem. In this paper issues related to ontology creation are discussed, and their relevance and importance is emphasized. The challenges and drawbacks of existing methodologies for ontology development are presented, and a possible solution is proposed.

A new methodology, offering a systematic approach for ontology development, is described in the paper. It includes components like rules, principles and classifications. All these components are described and their implementation is illustrated in the process of creation of one specific ontology in the field of e-learning. This ontology not only demonstrates the advantages of the proposed approach, but can be used for various learning purposes.

The importance of ontologies for the description of specific subject domains, and their capabilities for knowledge manipulation and learning resources management is further discussed.

II. SEMANTIC WEB, ONTOLOGIES AND EXISTING METHODOLOGIES FOR ONTOLOGY DEVELOPMENT ANALYSIS

Semantic web is extending the capabilities of traditional web by allowing data, information and resources to be formally described and easy manipulated by computers. Advantages of this approach allow information to be assembled and delivered according to the users' needs. Basic components of the Semantic web are XML, RDF and ontologies [16].

An ontology together with a set of individual instances of classes constitutes a knowledge base [7]. Ontology [21] is a combination of concepts, organized in taxonomies, their definitions and attributes, and extended with axioms and rules for reasoning. The following formula can be used:

$$O = \langle X, R, F \rangle,$$

where O stands for Ontology, X is for set of domain concepts, R – set of concept relations, and F is a set of functions that represent axioms and rules. Ontologies are very powerful instruments for learning resources management and exchange, but their development is a complex and difficult process. In this paper a survey of several existing methodologies for ontology creation was conducted, and advantages and drawbacks of these methodologies were analyzed. This survey was based on specific representative set of sources of information [1, 3, 4, 7, 9, 11, 12, 13].

In [4] a useful classification of ontology types is given (and used in the proposed approach), but it is not shown how to choose the most appropriate ontology language and ontology editor. In [3] ontology classification is defined and very useful principles are used (included in the described here approach, but extended with some new ontology languages and editors), but it does not offer clear criteria for appropriate ontology language and editor selection.

In [1] steps for ontology development process are described and detailed comparison of ontology editors is given, but it's drawbacks are missing ontology types classification, principles and clear criteria for ontology language choice.

In [7, 9] useful approaches for concepts and relations definitions were proposed (used partially in the proposed in this paper approach) but does not present solution for the principles and criteria for selection of most appropriate tools, languages and ontology types. In [11] principles, steps and approaches for methodology creation are given but the ontology types are not discuss.

In [12] very useful technical advices are given but it does not present theoretical classification and recommendations for the choice of the appropriate language.

In [13] basic features of well-designed methodologies are defined but it does not offer ontology types classification and criteria for editors selection.

The summary of the analysis of all the methodologies described, and comparison of their characteristics is presented in Table 1.

III. PROPOSED APPROACH FOR ONTOLOGY DEVELOPMENT

Proposed approach includes the most important phases and principles that should be followed when an ontology is designed and developed. On the base of the analysis performed the following features were identified as the most important ones, and were included as basic components of the Methodology proposed:

- Classification of ontologies
- Development principles
- Steps of development process
- Development approach
- Ontology languages selection
- Ontology editors choice

Detailed description of each methodology feature is presented in the next sections.

A. Classification of ontologies

Our approach is based on the classification of basic ontology types defined in [3, 4]. Ontologies are divided in two major groups:

- domain or task dependent, like task- or domain- oriented, common and applicable ontologies
- language dependent, like formal or informal (Fig.1).

Defining the type of ontology that will be developed is the first step in the process, and it is critical for it's quality and effectiveness as a technology for knowledge and learning resources manipulation.

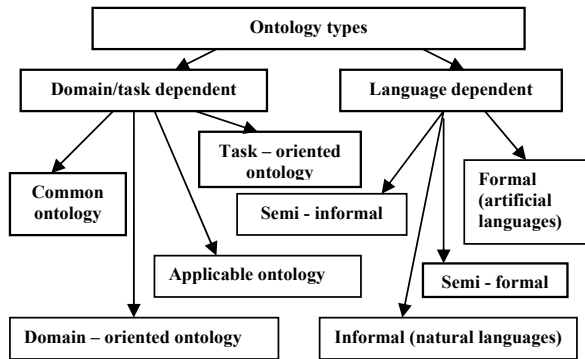


Fig. 1 Ontology classification [3]

B. Development principles

In the described here approach, we follow the five principles as defined in [10] - clarity, coherence, extensibility, minimal encoding bias, and minimal ontological commitment. Their purpose is to assure effectiveness of the defined concepts, reusability of created ontology as it is enough abstract and extensible.

C. Steps of the development process

Our approach is based on the set of the basic steps that should be followed in the process of ontology development as described in [1]:

1. Domain should be explored and basic concepts to be defined
2. Ontology design to be created and basic relations among concepts to be described.
3. Designed ontology has to be categorized according to proposed classification
4. Ontology has to be created following the principles described in B.
5. Ontology has to be tested for quality assurance
6. If it is approved by satisfying users' requirement and defined recommendation for its development, the Ontology can be published, used and reused in different learning contexts.

D. Development approach

Basic approaches used for ontology development are top-down, bottom-up, and combined one.

Top-down approach recommends first the main concepts to be defined and created using appropriate ontology editor, and after that more specific concepts to be created and connected to the basic concepts using the designed relations.

Bottom - Up approach recommends most specific terms to be created in the beginning. Combined approach is more flexible and seems to be the best solution, if the ontology editor chosen allows that approach to be used. It allows an ontology to be enlarged with new concepts independently of their level of concepts' hierarchy, and this way more expressive and powerful ontologies could be developed, as well as some mistakes in the process of design could be repaired.

E. Ontology languages selection

Extended classification of ontology description languages is proposed (Fig. 2), integrating traditional ontology languages (like Ontolingua [5], FLogic and OCML), web-based languages (like SHOE [26], OWL [30] and SWRL) rule-based languages (RuleML [15], SWRL [29]), ontology representation languages (Onolingua, XML, and UML), and ontology interchange languages (KIF[23], PIF). Criteria that should be used for ontology languages selection are proposed, by extending the criteria given in [15] for the availability of basic ontology elements (concepts, taxonomy, relations, etc.) and availability of additional tools (like query engines, translators, reasoning engines, user interfaces, etc) to provide support for the selection of ontology language and tools best matching user needs.

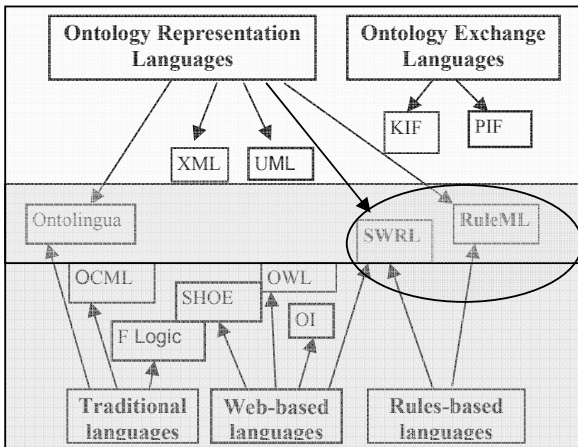


Fig. 2 Ontology languages selection [19]

F. Advantages of the proposed approach

Most important advantage of the proposed solution is the detailed description of steps that should be followed in order to create an ontology. Recommendations for principles, approaches that should be obeyed, and criteria for most appropriate

ontology languages and editors selection, that should be used, are other very important features of the proposed approach. Another advantage is linked with the included ontology types classification. The proposed approach generalizes best practices in the field of ontology development and could be easily modified and adjusted to the process of development of ontologies of different types and in different domains of science. A comparison of the main characteristics of existing approaches with the proposed new one is presented in Table 1.

TABLE I

Methodologies capabilities comparison

Sources	Ontology types classification	Principles for development	Steps	Approach	Ontology language	Ontology editors choice
[1]	-	-	+	-	-	+
[3,4]	+	+	+	+	-	-
[7,9]	-	-	+	+	-	-
[11]	-	+	+	+	-	-
[12]	-	+	+	+	+	-
[13]	-	+	+	+	+	-
New	+	+	+	+	+	+

Sign “+” is used to represent the availability of a characteristic, sign “-” is used to represent a missing characteristic.

In the next chapter we describe how the proposed approach was used for the development of e-learning ontology.

IV. DEVELOPING E-LEARNING ONTOLOGY

A. Description of the ontology

The systematic approach for ontology development described in previous chapters, was applied in the process of e-learning ontology creation.

It was decided not to develop this new ontology from scratch, but to start with one existing classification of the E-learning concepts, developed by Marisa Trigari - EBT thesaurus [8]. It was extended by adding additional concepts in the field of e-learning and related subject domains, defined in the process of subject domain research. Experience of many specialists in the field of Technology Enhanced Learning (TEL) was used and applied in the definition of all extensions to the basic EBT thesaurus.

The relations among concepts in the EBT thesaurus - Related To (RT) and NT x ($x=1,2,..$), that define different level of abstraction, were modified to improve expressiveness of the developed ontology.

They were combined with those used in the development of ICT ontology [20] (developed as part of 5FP Project DIOGENE) - HP (Has Part), R (Requires) and SO (Suggested Order). They are presented in details in [18].

Additional relations are needed to describe specific relationships among concepts in the field of e-learning. They are described in the next section. Proposed relations allow all links between concepts to be defined clearly, exactly and in details. Thus effective search and delivery of most appropriate learning content could be implemented and most effective and high quality education for the specific domain of science to be achieved.

An example of the ontology developed:

1. E-l onto

1.1. Types of learning

1.1.1 Traditional learning

1.1.1.1 Definition

1.1.1.2 Characteristics

1.1.1.3 Advantages

1.1.1.4 Problems

1.1.2 E-learning

1.1.2.1 Definition

1.1.2.2 Characteristics

1.1.2.2.1 web-based content

1.1.2.2.2 online assesment

B. Proposed relations

The relation ‘‘Related To ‘ is used to represent links between basic concepts, which can be learned together. This way learner is directed to other concepts, appropriate to be learned together with the current one. In such a way a possible learning path is proposed to the learner. Another very important relation is ‘‘Includes’’, describing the relationship between several sub-concepts and corresponding basic concept. This relation could be applied in different levels of ontology hierarchy. The third relation is ‘‘Predecessor of’’, representing the evolution of existing concepts.

- $RelatedTo(X, Y_1, Y_2, Y_3, \dots, Y_n)$ defines connection among defined concepts X and $Y_1, Y_2, Y_3, \dots, Y_n$
- $Includes(X, Y_1, Y_2, Y_3, \dots, Y_m)$ defines that all concepts $Y_1, Y_2, Y_3, \dots, Y_m$ are sub-concepts of the concept X
- $PredecessorOf(X, Y)$ defines that concept X has appeared before concept Y and concept Y is an extension or improvement of term X

All proposed relations are shown on Fig. 3.

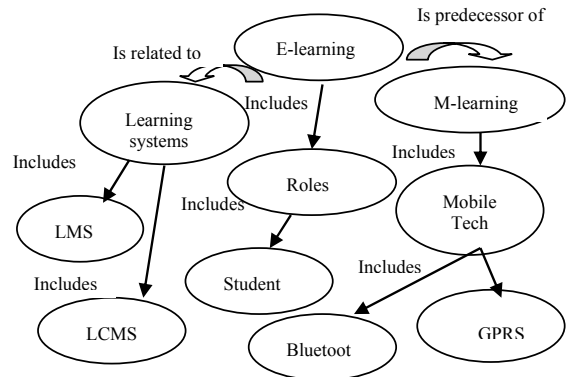


Fig. 3 Structure of created e-learning ontology

For example:

- E-learning is predecessor of m-learning – $PredecessorOf(e-learning, m-learning)$
- e-learning includes concepts like Roles, that has another concept Student – $Includes(e-learning, roles)$, $Includes(roles, student)$
- e-learning is related to learning systems – $RelatedTo(e-learning, learning\ systems)$.

C. Protégé capabilities

On the base of conducted ontology editors survey [19], Protégé editor [6], proposed by Stanford University, is selected as the most appropriate tool for e-learning ontology creation and management. It supports various ways of graphical visualizations of the concepts and relations, and metadata descriptions for each concept and relation from the ontology developed (Fig. 4). This way all the information can be searched, delivered and assembled in a flexible way, depending on the learning context.

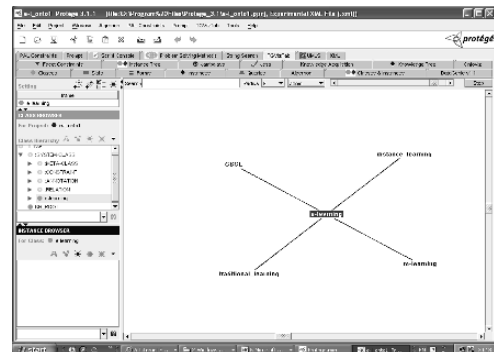


Fig.4 Vizgraph capability

Basic functionalities of the editor allow classes, instances and relations among them to be defined. Different adds-on can be included or excluded so most flexible and user-friendly interface to be used for implementation of different ontology features.

D. SWRL

On the base of conducted ontology description languages analysis, discussed in details in [19] and summarized in this paper, SWRL [29] was chosen as the most appropriate language for the purpose of e-learning ontology development.

It's main advantage is the capability for description of reasoning rules and their implementation in best learning path selection. This feature makes it possible to achieve flexible and adaptive learning strategies, which is one of the main objectives of advanced e-learning systems. The learning path is generated on the base of learners' pre-requisites, actual knowledge and preferences, expressed through relations among ontology concepts and defined reasoning rules.

V. APPLICATION OF ONTOLOGIES IN E-LEARNING

Ontologies are defined as powerful means for knowledge and learning resources management and exchange. Their application in the learning content management is presented on Fig. 5. The concept of knowledge repository abstraction proposed by Berman, Fox and Hey [17] is modified to represent the idea of design and modeling of Learning Content Management System (LCMS) as Learning Objects Repository (LOR). Learning resources could be a separate word document, html page or another type of digital information. It could be organized as Learning Object (LO) or Learning Unit (LU) in all variations of these concepts definitions. Learning resources have to be stored in a repository. This repository could be a standalone application, or part of the Learning Content Management System (LCMS). One of the most appropriate and useful ways for learning content organization is based on the use of Ontology for representing the basic domain concepts, and to connect each ontology concept to one or more LOs packaged with all the relevant and standardized metadata information. Therefore it is convenient LCMS to be designed and modeled as containing the LOR. In such a way LCMS will contain learning resources (Los with meta-data files) organized by the ontology hierarchy levels, relations and defined reasoning rules.

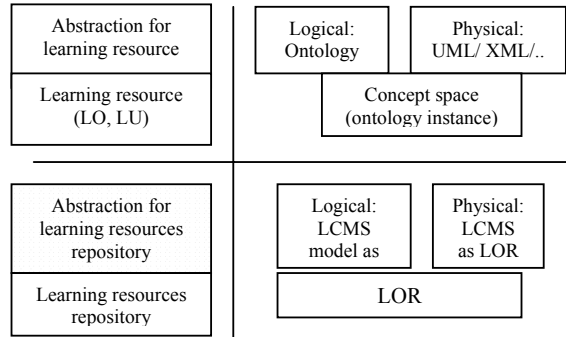


Fig. 5 Learning objects repository (LOR) abstraction adapted by Berman, Fox and Hey)

Integration of ontologies in the entire process of learning content capturing, representation, management and delivery, in relation with management of other digital entities, is presented on Fig. 6. Different techniques defined by Berman, Fox and Hey [17] like folders, semantics and concept relations for different types of digital entities (knowledge, data and information) are presented. They are stored in a kind of repository that has to manage their organization and delivery – users' access to the specific entity.

Proposed characterization is extended with new type of digital entity management: manipulation and delivery of learning content. It has to be structured by ontology concepts, relations, axioms and reasoning rules. Afterward learning resources are stored in a LOR and they are delivered to the learners depending on their meta-data characteristics and learners' preferences and educational needs. In this way a flexible and adaptive learning process is provided and high quality of education is achieved.

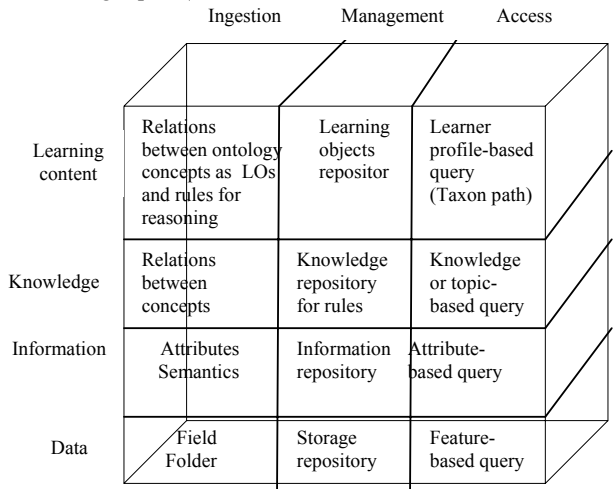


Fig. 6 Application of ontologies in e-learning for digital entity management (adapted by Berman, Fox and Hey)

VI. CONCLUSION

A systematic approach for ontology development is described in details in the paper. It contains a classification of different types of ontologies. Basic steps are presented and rules for ontology creation and proper selection of most appropriate ontology description languages and ontology editors are listed. Described approach is implemented for creation of e-learning ontology and results are presented and discussed in the article. The main results achieved are in presenting systematic process of ontology creation and highlighting the ontology capabilities for subject domain representation and learning resources manipulation.

A new methodology for ontology development is presented, that brings together in a systematic approach for ontology creation: ontology types classification; principles and approaches for ontology creation; steps and criteria for ontology languages and tools selection. An ontology in the field of e-learning was created in order to test the proposed methodology.

Future work is related to research of capabilities of ontologies as technology for m-learning content delivery. In this particular case the learning material has to be organized and presented as LOs or Learning Units that are small and independent pieces of the learning content. These small units of information have to be easily delivered via mobile technologies and to be displayed on small displays of mobile devices. In the same time they could be assembled in flexible way according to the requirements of the mobile learner, and to provide learning on demand whenever and wherever it is requested.

ACKNOWLEDGMENT

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An Encyclopedia of Software Resources – A Possible and Realistic Project?

Liciniu-Alexandru Kovács
Faculty of Business, "Babes-Bolyai" University
7 Horea Street, 400174 Cluj-Napoca, Romania
<http://www.geocities.com/liciniu/index.html>

Abstract: Personally, I strongly believe that it is very difficult to imagine today's civilized world without computers and Information Technology. Within a relative short period of time, computing has been implemented in all the possible domains of activity. Technology has developed rapidly and the notions of information society and knowledge-based society have become familiar. In my view, there is no doubt that the humanity's future goals cannot be accomplished without a solid understanding of how to use a computer properly and of the art of computer usage. In this sense, all of us who aim to be well informed and productive need to understand not only a limited number of specific software applications to work with, but also to have the possibility to access valuable information about software packages of all kinds. Starting from the definition of an encyclopedia as "A book, or set of books, or digital version of such, containing authoritative information about a variety of topics..."¹, in this paper I will try to show that this Encyclopedia of Software Resources which I envisage will be a collection of information related to all possible software applications, very useful for students, for developing specific lessons/courses, for the research community, the industry, and the general public.

Key words: information society, knowledge-based society, open source, computer-based learning (CBT), Web-based tutorials, software resources, software classification, software features, software packages, tutorials, multimedia, platform-independent tutorial, comparative approach.

NOTE: A few months ago, I sent a paper to IDPT 2006 World Conference on Integrated Design & Process Technology, held in San Diego, CA, on June 25-30. The paper [2], which presents a Web-based tutorial as an example of a comparative approach to word processing, concludes by launching *the idea* of an encyclopedia of software resources. Unfortunately, I could not effectively participate in the conference and therefore I did not have the chance to introduce this idea to the audience. That is why I avail myself of this opportunity to re-launch, with many more arguments, this project to build an encyclopedia of software resources. The IDPT 2006 paper [2] is freely downloadable from my personal website.

I. INTRODUCTION

The Internet and a great number of dedicated conferences, events, and summits offer a huge amount of papers about information society and knowledge-based society. I will herein mention just two aspects:

¹ <http://faculty.valencia.cc.fl.us/jdelisle/lis2004/glossary.htm>

1. "What do we mean by an "information society"? We mean one in which human capacity is expanded, built up, nourished and liberated, by giving people access to the tools and technologies they need, with the education and training to use them effectively. The hurdle here is more political than financial. The costs of connectivity, computers and mobile telephones can be brought down. These assets – bridges to a better life – can be made universally affordable and accessible. We must summon the will to do it.

The information society also depends on networks. The Internet is the result of, and indeed functions as, a unique and grand collaboration. If its benefits are to spread around the world, we must promote the same cooperative spirit among governments, the private sector, civil society and international organizations."²

2. "Citizenship and governance must evolve with a view to increasing globalization, European integration and Union enlargement and the emergence of new forms of cultural identity and social dialogue. Specifically, the Union will support:

- transnational comparative studies and research and the coordinated development of statistics and qualitative and quantitative indicators;
- interdisciplinary research to support the policies of Member States;
- the creation and Europe-wide use of research infrastructures and data and knowledge bases."³

Thus, from our observation of the development processes and from our day-to-day activity, the above remarks and the information found on the Internet, we can come to the conclusion that, in the near future, we will need a specific interdisciplinary product, based on collaborative and comparative studies and with accessibility via networks around the world. This product is to be a large multimedia, hypermedia or even a virtual reality software package. It will be based on quality computer programming and will be "consulted" through universal viewers, e.g. browsers under

² Statement by H.E. Mr. Kofi Annan, Secretary-General of the United Nations, World summit on the information society, Tunis, 16 November 2005. Source: <http://www.itu.int/wsis/tunis/statements/docs/io-un-opening/1.html>

³ Citizens and governance in a knowledge-based society. Source http://ec.europa.eu/research/fp6/index_en.cfm?p=7

any operating system. Today's information technology with all its ingredients makes all this possible. This product's name might be An Encyclopedia of Software Resources.

II. RELATED MATERIALS

If we do research on the Internet, we can find material that can sustain the idea of an Encyclopedia of Software Resources. In the following, I will mention only three of them, but I am absolutely sure that one can find many other examples in libraries, databases and on the Internet.

The first material is **Linux Software Encyclopedia** by Steven K. Baum, Texas A&M University⁴. It seems that it was last updated on March 8, 2001. Being very close to the idea of an Encyclopedia of Software Resources, some pages of this site contain:

- **Programming Texts and Tutorials** – a list of freely available documents (i.e. tutorials, books, guides, reference manuals, etc.) for learning how to program in various languages as well as about various Linux and UNIX related topics⁵;
- **Software Metasites** (fig. 1) – a list with available software for specific application areas like Astronomical Software and Documentation, Biological Software and Databases, Chemical Informatics, CodEc for Economics and Econometrics, International Cryptography, Fuzzy Logic and Neurofuzzy Software, Linear Algebra Software, Machine Learning Resources, Operating Systems Projects, Pattern Recognition and Image Processing, Seismological Software Library, Software Engineering Resources and many more⁶.

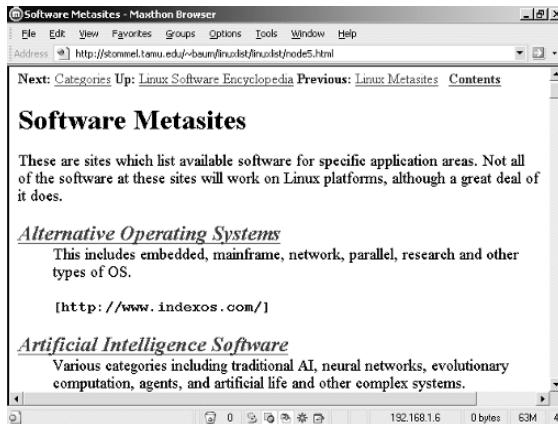


Fig. 1. Software Metasites
A list with available software for specific application areas

⁴ <http://stommel.tamu.edu/~baum/linuxlist/linuxlist/linuxlist.html>

⁵ <http://stommel.tamu.edu/~baum/programming.html>

⁶ <http://stommel.tamu.edu/~baum/linuxlist/linuxlist/node5.html>

The second material is the **Computer User High-Tech Dictionary** (fig. 2). Without going into detail, I will mention only that the dictionary is limited to explaining different specific IT&C terminology.



Fig. 2. The Computer User High-Tech Dictionary
(<http://www.computeruser.com/resources/dictionary/>)

The third material, which may be a future competitor of an Encyclopedia of Software Resources, is **Wikipedia** – The Free Encyclopedia. Fig. 3 and fig. 4 present a general description of software and a comparison.

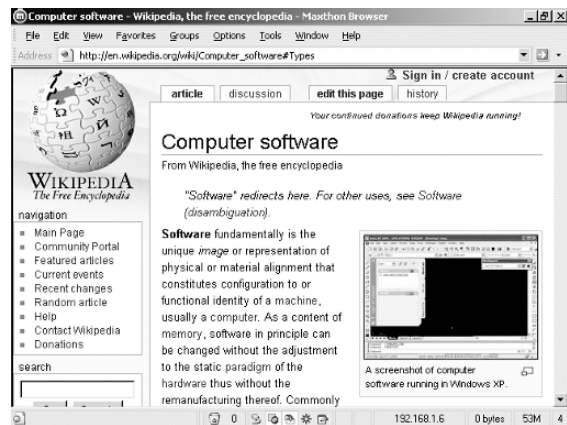


Fig. 3. Wikipedia – The Free Encyclopedia
A general description of software

III. SOFTWARE RESOURCES

The market offers a wide selection of more and more integrated software packages. A possible classification of well known software resources, available around year 2000, with some of their corresponding products is as follows [1]:

- Operating systems: DOS, Windows, Unix, Solaris, Linux;

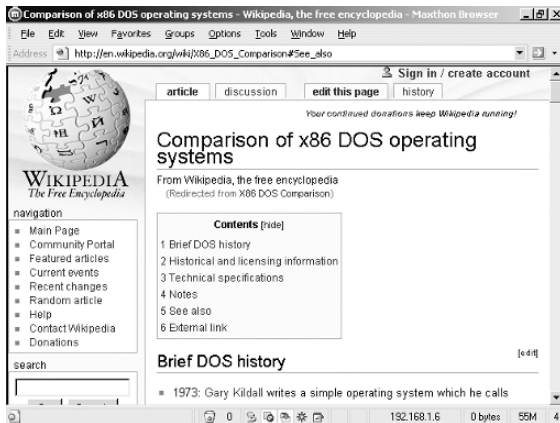


Fig. 4. Wikipedia – The Free Encyclopedia
Software comparison

- Word processors: Word Star, WordPerfect, Word, QuarkXpress;
- Spreadsheets: Lotus 1,2,3, QuattroPro, Excel.
- Database Management Systems: dBASE, FoxPro, Access, Paradox, Oracle;
- Graphic and Presentation packages: Astound, Bravo, Asymedia, Charisma, Power Point, WordPerfect Presentations, Freelance Graphics, SmartDraw Pro, Corel Draw, Macromedia Action, Persuasion, Stanford Graphics, Adobe Illustrator, Macromedia Freehand, ABC Graphics, GSP Design Works, Windows Draw;
- DeskTop Publishing software: Xpress, PageMaker, Ventura, Page Plus, Publisher, Frame Maker, Canvas, ipublish, PressWorks;
- Voice Recognition software: Voice Type Simply Speaking, Via Voice, Voice Command, Dragon Dictate, Naturally Speaking, Voice Pad;
- Digital Video software: Adobe Illustrator, Adobe After Effects, Ulead Media Studio;
- Optical Character Recognition software: Inovatic Easy Reader, OmniPage, Recognita, TextBridge, Ocron Perceive Personal;
- Computer Aided Design software: AutoCAD, CorelCAD, Corel Visual CADD, Design CAD, Drafix CAD Pro, MicroGDS Pro;
- Browsers: Internet Explorer, Navigator, Opera, HotJava Browser;
- Remote connection software: LapLink, Carbon Copy, pcANYWHERE, CoSession Remote, ReachOut;
- Videoconference software: Captivator, Net Meeting, Intel Proshare Conferencing System, VideoLogic;
- Antivirus software: BitDefender, Dr. Solomon's Home Guard, F-Secure Anti-Virus, IBM AntiVirus, McAfee VirusScan, Norton Antivirus, PC-cilin, VDS Pro, VET Antivirus, Sophos Antivirus;

- Visual Programming Languages: Visual J++, Java Workshop, Delphi, Optima, Power Objects, Power Builder, Visual Basic, Visual C++, Visual FoxPro, Visual Café, JBuilder, Visual Age;
- Multimedia Authoring software: IconAuthor Net Edition, ToolBook II Instructor, MacroMedia Authorware, Macromedia Director, CBT Express, Click & Create, Illuminatus, Dazzler, MatchWare Media8or, Multimedia MM 200, Immedia.

I stress that the above list (completed with tables that contain comparative data) was “valid” for the year 2000. Since then, there have been great advances in computer science, with Microsoft still remaining top of the software market. Thus, Sun Microsystems has spent a lot of energy and millions of dollars on the development of Solaris operating system, Linux and Linux-related magazines have become easily accessible, OpenOffice.org 2.0, Star Office 8.0 and many more complex software resources are available to the users.

Starting from the possible classification of software resources presented in my tutorial written in Romanian for Romanian students (fig. 5, fig. 6, fig. 7 and fig. 8), and taking into consideration the introduction and the related materials, we can conclude as shown in the ensuing section.

THE IDEA

- refine the above classification;
- make an inventory of all the types of software existing on the market;
- elaborate a material dedicated entirely to software resources, such as Home Edition, Enterprise Edition, Professional Edition, etc.;
- organize the entire material into a classical and electronic dictionary with cross-references among keywords;
- give examples of screen captures, photos, graphics, sounds, and digital video for the software resources found and place them on one or more (HD)-DVDs, Blue Ray or holographic storage media;
- provide tutorials – comparative approach about basic functions explained in common, natural language;
- place the whole material and the examples in university intranets and libraries so that all members of the community can access them at any time; part of it may even become an open source;
- provide the electronic version with a complex local search engine;
- if developed for the intranet/Internet, introduce the following types of pages: Home page, Index pages, Content pages, Study pages, and Evaluation pages;
- provide ways to complete the material with new topics (a kind of Wikipedia);
- publish the book and the high-capacity storage media as The Encyclopedia of Software Resources.

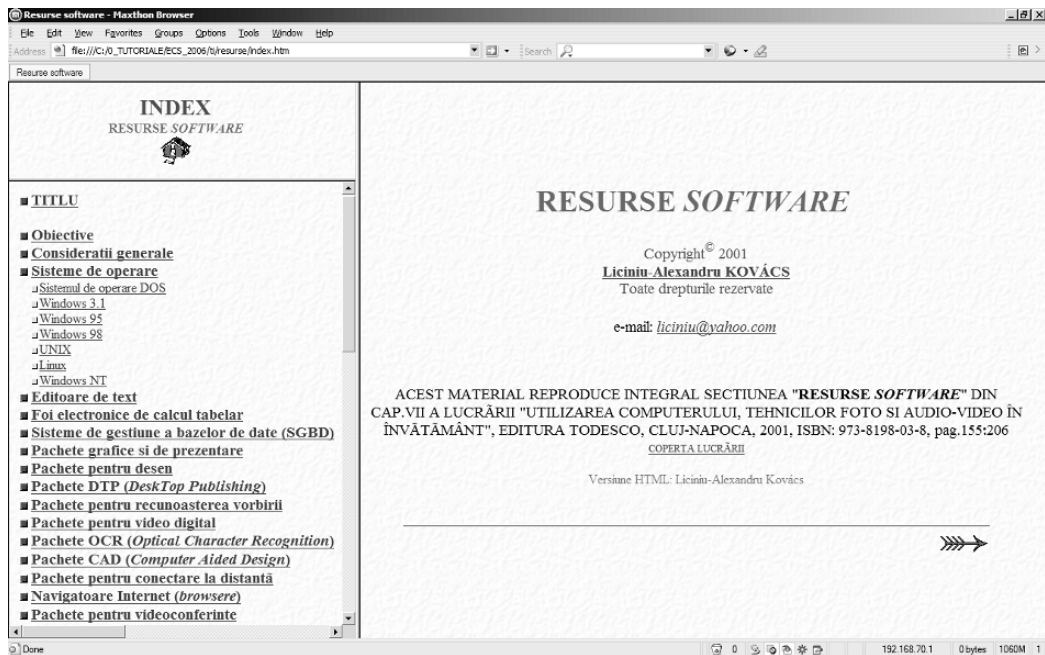


Fig. 5. Software resources – tutorial written in Romanian for Romanian students (main page)

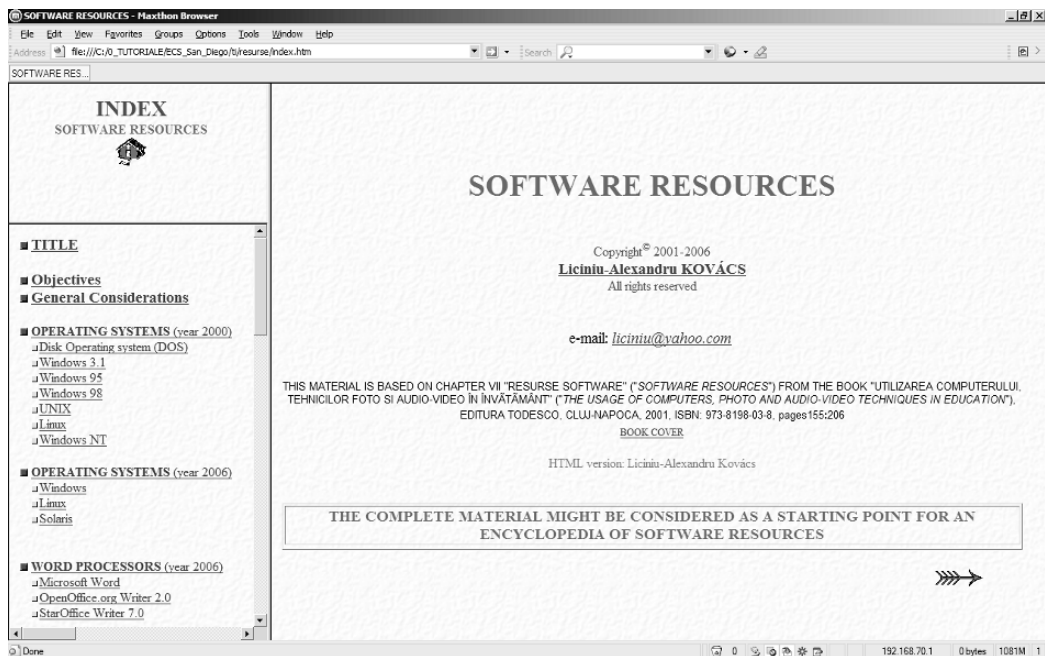


Fig. 6. Software resources – the above main page, updated with new topics and translated in English

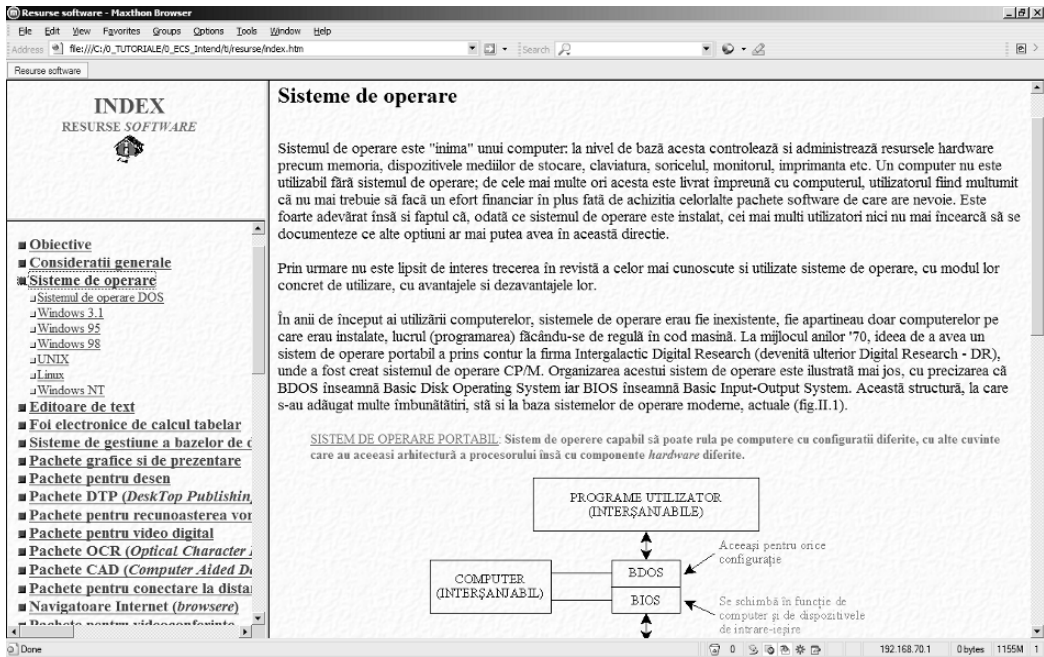


Fig. 7. Software resources – details about operating systems

Pachete pentru desen (I) - viziune comparativa - Maxthon Browser

Address: file:///C:/O_TUTORIALE/O_ECS_Intend/t/Resurse/desen_11.htm

Pachete pentru desen (I) - viziune comparativă

Produsul	Adobe Illustrator 4.1	Macromedia Freehand 5.0	CorelDraw 6.0	ABC Graphics Suite
Cerinte minimele	386, 4 MB RAM Windows 3.0	486, 12 MB RAM Windows 3.1	386, 8 MB RAM Windows 3.1	386, 8 MB RAM Windows 3.1
Spatiu pe disc	12 MB	25 MB	40 MB	15 MB
Versiune Win'95	Nu	Da	Da	Da
CD-ROM	Da	Da	Da	Da
Pagini multiple	Da	Da	Da	Da
Support OLE2	Da	Da	Da	Da
Straturi	Da	Da	Da	Da
Ajutor online	Da	Da	Da	Da
Trace	Da	Da	Da	Da
Blend	Da	Da	Da	Da
Grafice	Da	Nu	Da	Nu
Text mulat	Da	Da	Da	Da
Conversie text mulat	Da	Da	Da	Da
Kenning	Da	Da	Da	Da
Modele color	CMYK, Pantone, Tpyo, Focoltone, Trumatch	CMYK, DIC, Tpyo, Focoltone, Trumatch	CMYK, RGB, HLS, Focoltone, Trumatch	RGB, HLS, CMYK
Separare culori	Spot & CMYK separator s/w	Spot & CMYK	Spot & CMYK	Nu
Support pt. formatele				
BMP	Da	Da	Da	Da
CGM	Da	Da	Da	Da
CDR	Da	Da	Da	Da

Fig. 8. Software resources: drawing software packages – comparative approach

MOTIVATIONS

- As far as we know, there is no dedicated material on the market in encyclopedia format;
- A dictionary of software packages, even illustrated, is not sufficient;
- A tutorial covers usually only one software resource;
- The comparative approach generates competition on the software market which is highly desirable from the end-user point of view;
- The IT&C and the software industry is too important for all of us and thus is to be avoided the monopoly stage in this sectors;
- It is a strong necessity to build a place where to meet (ideally) all the software applications.

TARGET "MARKET"

- This reference resource can be used primarily to develop specific lessons/courses in education units like universities, colleges, and high schools – in this sense, we can mention that there is no course entirely dedicated to software resources;
- The Encyclopedia of Software Resources will be useful for the research community;
- The Encyclopedia of Software Resources will be useful for the medical community, the industry, etc.;
- The Encyclopedia of Software Resources will also be useful to the general public, as it can help the potential (end)-users understand what information and knowledge-based society means.

OBJECTIVES

- To help (end)-users understand clearly what specific software packages are good for;
- To provide a reference source that explains what can be done with a certain software package;
- To integrate knowledge of software resources in the education system and in the society.

MEANS AND TECHNIQUES

- The entire material or just some specific sections of it can be organized according to CBT standards as multimedia, hypermedia or virtual reality.
- The project structure is to be debated and designed by a (large) team of professors, engineers, specialists, and software end-users.
- The software resources might be structured according to something similar to Universal Decimal Classification (U.D.C.). In this sense, a particular software resource can be easily correlated to the corresponding domain.

NAVIGATIONAL STRUCTURE

- This suggested Encyclopedia of Software Resources might be based on a complex composite navigational structure used in multimedia applications described by T. Vaughan – fig. 9 [4].

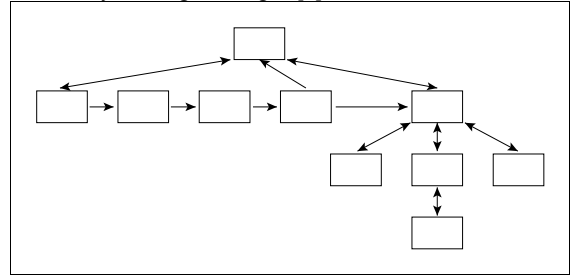


Fig. 9. Composite navigational structure

RESEARCH

- After collecting and organizing the material, further research will be done to determine the optimum quantity of multimedia for the printed version and high-capacity storage media's content in order to ease the operation of finding a certain software resource and have a maximum transfer of information toward the students and/or other users.

IV. CONCLUSIONS

If we start from the title of this paper, "*An Encyclopedia of Software Resources – A Possible and Realistic Project?*", the only possible answer is **YES!**

Acknowledgment – I am grateful to Ms. Emilia Plăcintar for revising this paper.

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Undergraduate Students Assessment on Materials Chemistry Topic using an Auto-Calibrated Online System

Lorentz JÄNTSCHI¹, Carmen Elena STOENOIU¹, Sorana Daniela BOLBOACĂ²

¹Technical University of Cluj-Napoca, 15 Constantin Daicoviciu Street, 400020 Cluj-Napoca, Romania, E-mails:

lori@academicdirect.org, carmen@webmail.academicdirect.ro

²"Iuliu Hatieganu" University of Medicine and Pharmacy, 13 Emil Isac Street, 400023 Cluj-Napoca, Romania, E-mail:

sbolboaca@umfcluj.ro

ABSTRACT - Development of communication and information technology had an important impact on teaching, learning and knowledge assessment. According with national trends in objective evaluation of undergraduate students' knowledge, starting with experiences obtained by creation of the multiple choices examination system for general chemistry, an auto-calibrated online evaluation system has been developed. The aim of the research was to assess the first year undergraduate students' knowledge on materials chemistry topic at the Faculty of Materials Science and Engineering, the Technical University of Cluj-Napoca, Romania by using the developed auto-calibrated online evaluation system. The testing and evaluation methodologies are presented. The students' performances in terms of individual correct answers score and the average time per correct answer were collected and analyzed. The proposed auto-calibrated online evaluation system proved to offer a stable and valid evaluation environment for undergraduate students' knowledge assessment on materials chemistry topic.

KEYWORDS - Computer Assisted Evaluation; Undergraduate Students; Knowledge Evaluation; Materials Chemistry Topic

INTRODUCTION

Development of communication and information technology had an important impact on teaching, learning and assessment at all levels of formal education: kindergarten [1], primary education [2], secondary education [3,4], post secondary education [5]. The teaching profession is seen in the new technology era as *evolving from an emphasis on teacher-centered, lecture-base instruction to student-centered, interactive learning environment* [6]. According with the development of information and communication technology, the educational system all over the world is confronting on one hand with challenge of transforming the curriculum and educational process to provide students with the skills needed in order to function effectively in the actual dynamic, information-rich, and continuously changing environment and on other hand with development of objective, fast and equitable students' knowledge assessment methodologies and environments.

The advantages offered by the information and communication technologies in training and educational process can be summarized as follows:

- Facilitate organizational learning, by transforming tacit knowledge into explicit knowledge [7];
- Provide educational access across the country and across the globe [8];
- Provide new tools to support collaborative learning [9];
- Emphasis the instructional process based on relationships, inquiry and intervention [8];
- Provide an environment which allows the teacher to give students more options and responsibilities for their own learning [10];
- Promote active learning in the learning process, producing and sharing knowledge, and participating as expert [11].

At higher education level, computers are used also as instruments in the students' knowledge assessment, being found as common type of evaluation in sciences and applied sciences domains: computer science [12], engineering [13], medicine [14], health sciences [15], pharmaceuticals [16], etc.

According with the necessity of development of an objective system for students' knowledge evaluation at university level, starting with experiences obtained by creation of the multiple choice examination system for general chemistry [17,18], an auto-calibrated online system has been developed [19] and assessed [20]. The materials chemistry knowledge assessment of the undergraduate first year students' was study by using the auto-calibrated online system and the obtained results are presented.

MATERIAL AND METHOD

At Technical University of Cluj-Napoca, Romania, Materials Sciences and Engineering Faculty, the curriculum contains as core course for the first year of study the Materials Chemistry topic. According with course description and with the subject matter, the Materials Chemistry course contains tutorials and laboratory sessions; at the end of the course there is an examination for students' knowledge assessment. In the university year 2005-2006, there were enroll in the first year of

study at the Materials Sciences and Engineering Faculty a number of ninety-nine students. All students participated at the lectures (PowerPoint presentations) and laboratory sessions that included practical activities and/or computer aided learning environments. Full copies of materials were available and the students had the possibility to enroll voluntarily into the team responsible for creation of the multiple-choice questions (MCQs) banking.

The imposed rules in multiple-choice banking creation were as follows:

- Each question has a statement or a situation (steam) and a list of five suggested solutions (options);
- Each question has at least one and no more than four correct options;
- On the received subject matter, each student that enrolled in the MCQs banking creation was reasonable by creation of proportional number of questions with one, two, three and respectively four correct options.

Each student that completes the assumed activities received bonus points to the final mark, according with the quality of work. For example, if the student respects the proportion between questions with one, two, three and four correct option receives a number of points as bonus. Penalties were applied (a number of point were subtract from the bonus points) when the imposed rules in MCQs creation were not respected and when the created questions were wrong (errors in statement and/or in option(s)).

The methodology of undergraduate students' knowledge assessment included:

- Place of the examination: at test center;
- Type of examination: computer- and teacher-assisted;
- Period and time of examination: according with the structure of academic year and with the students and teacher schedule;
- Number of MCQs: thirty;
- Generation of the MCQs tests: double randomization from MCQs banking (randomization of the statement and randomization of the options order);
- Number of tests: as many time as the student desired in the imposed period of time and according with the schedule;
- Penalties when the student gives up shortly after the beginning of an evaluation.

The applied score and results methodologies contained the following specifications:

- Each question received one point if all the correct answers and none of the distracters (the incorrect answers presented as a choice) are selected, and zero points otherwise: *all-or-none rule*;
- At the end of the evaluation, students' identification data, the time when the test begun and ended, the number of correct answers and the average time needed to give a correct answer are displayed;
- Starting from the distribution of the individual scores (which include the number of correct answers and the average time per correct answer) the system assigned to the lower score the mark

equal with four (the exam is failed) and to the highest score the mark equal with ten (ten being the best mark). The students' marks were auto-calibrated each time when a student performed an evaluation.

All students from the Faculty of Materials Science and Engineering were included into the study. They had the possibility to familiarize with the evaluation environment before final examination as many time as they wished. A number of five variables were collected from each evaluation during the imposed examination period (June 6, 2006 - June 27, 2006): students' first and second name, data and time when the test begin and end (as yy.mm.dd hh.mm.ss format), the number of correct answers, and the average time needed to give a correct answer. Data were collected into a database and were summarized and analyzed with Statistica at a significance level of 5%. The 95% confidence intervals for proportions were calculated by using of an original method, based on the binomial distribution hypothesis [21].

RESULTS

The auto-calibrated online evaluation system on materials chemistry has been developed and is available via the address: http://vl.academicdirect.org/general_chemistry/materials_chemistry/, the access being restricted to the test center by checking the IP addresses.

Each student performed at least one time the materials chemistry test by using the auto-calibrated online evaluation system. For each student the system generated a test with thirty MCQs out of eight hundred sixty-one. The MCQs banking contained: 34.4% questions with one correct option (95%CI [31.3, 37.7]), 23.2% questions with two correct options (95% CI [20.5, 26.2]), 20.9% questions with three correct options (95%CI [18.3, 23.8]) and 21.4% with four correct options (95%CI [18.7, 24.3]).

The distributions of the number of evaluations expressed as absolute and relative frequencies and 95% confidence intervals for the absolute frequency are presented in table I.

TABLE I
DISTRIBUTION OF THE NUMBER OF EVALUATIONS

Test	Students		
	No.	95% CI	f _r (%)
One	12	[6, 10]	12.12
Two	55	[45, 65]	55.56
Three	20	[13, 29]	20.20
Four	9	[4, 16]	9.09
Five	1	[0, 5]	1.01
Six	1	[0, 5]	1.01
Seven	1	[0, 5]	1.01
Total	99	[95, 99]	100

The range of days between two evaluations, when were applicable, varied from zero (the student performed the evaluation twice in the same day) to 21 days. The intervals

between two examinations were in 75.75% cases less than or equal with 10 days. Nine students out of ninety-nine (95%CI [4.05- 16.15]) performed the test twice in the same day.

In conformity with the specification of the auto-calibrated online system, when the students had more than one evaluation, the less performing results (in terms of the correct answers score and/or the average time per correct answer) was not took into consideration in computing the final mark. Statistical characteristics (express as average – mean, median, mode, standard deviation – StdDev, minimum – Min and maximum – Max) of the correct answers score (C_{ip}) and of average time per correct answer (C_{tm}) were summarized in table II.

TABLE II
SCORES STATISTICAL CHARACTERISTICS: CORRECT ANSWERS AND AVERAGE TIME PER CORRECT ANSWER

Test	Characteristic	Mean	Median	Mode	StdDev	Min	Max
First	C_{ip}	12.00	11.40	5.3	6.07	0.8	24.7
	C_{tm}	1.64	1.24	1.23	1.13	0.15	4.76
Second	C_{ip}	16.07	16.25	17.4	6.45	3.8	30.2
	C_{tm}	2.51	2.17	2.13	1.49	0.29	6.64
Third	C_{ip}	17.63	17.75	N.A.	6.70	7	27.6
	C_{tm}	2.86	2.57	N.A.	1.52	0.71	5.76
Forth	C_{ip}	20.33	19.90	N.A.	1.69	18.9	22.2
	C_{tm}	3.38	3.48	N.A.	0.52	2.81	3.84
Sixth	C_{ip}	21.65	21.65	N.A.	5.87	17.5	25.8
	C_{tm}	3.55	3.55	N.A.	1.87	2.23	4.87
Seventh	C_{ip}	23.00	23.00	N.A.	N.A.	N.A.	N.A.
	C_{tm}	3.98	3.98	N.A.	N.A.	N.A.	N.A.

StdDev = standard deviation; Min = minimum; Max = maximum; N.A. = not applicable
 C_{ip} = correct answers score; C_{tm} = average time per correct answer

Twenty students out of ninety-nine (20.20%) performed the examination by three times. The less performing test in terms of number of correct answers score or average time needed to give a correct answer score was withdrawn. The distributions of the evaluations correct answers scores give by the students which performed the test three times are presented in figure 1 (the students' id are from left to right: std_6, std_11, std_15, std_17, std_18, std_19, std_20, std_23, std_27, std_35, std_37, std_40, std_48, std_58, std_67, std_74, std_78, std_81, std_88, and std_99).

Nine students out of ninety-nine (9.09%) performed the test by four times. For this sample of student, the graphical representation of the testing points after the less performing test were withdrawn were presented in figure 2.

The comparisons between the correct answers scores and of the average time needed to give a correct answer score according with the number of test were summarized in table III. Note that the comparisons were performed between results obtained at the initial and at the final evaluation.

Comparison of the correct answers score obtained by students at the initial and final evaluations (after withdrawn of the less performing test) shown that the average of the testing points were statistical significant higher at the final (18.741) evaluations

comparing with the initial (8.675) evaluation ($p < 0.0001$, $n_{valid} = 32$, see also figure 3).

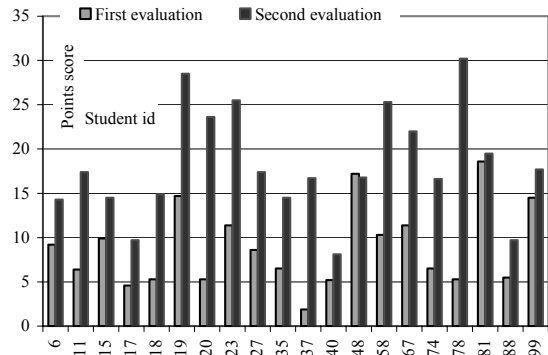


Figure 1. Distribution of the correct answers scores for sample of students that performed the evaluation by three times

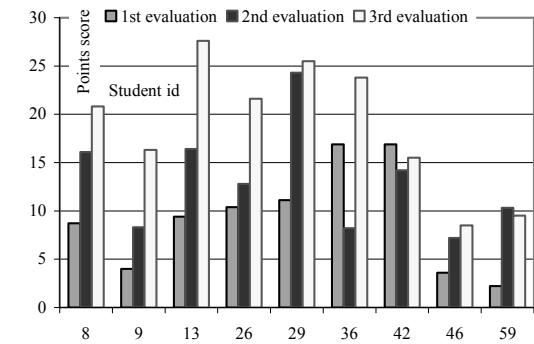


Figure 2. Distribution of the correct answers scores for sample of students that performed the evaluation by four times

TABLE III
COMPARISON BETWEEN TESTS: CORRECT ANSWERS SCORE (C_{ip}) AND AVERAGE TIME NEEDED TO GIVE A CORRECT ANSWER (C_{tm})

No. of tests	First test			Last test			p-a C_{ip}	p-a C_{tm}
	a C_{ip}	a C_{tm}	n_{valid}	a C_{ip}	a C_{tm}	n_{valid}		
One	10.68	1.322	12	N.A.	N.A.	N.A.	N.A.	N.A.
Two	14.22	2.052	55	N.A.	N.A.	N.A.	N.A.	N.A.
Three	8.915	1.103	20	18.145	2.891	20	< 0.0001	< 0.0001
Four	9.244	1.070	9	18.789	3.158	9	< 0.005	< 0.005
Five	4.30	0.40	1	18.90	2.81	1	N.A.	N.A.
Six	9.60	0.97	1	25.8	4.87	1	N.A.	N.A.
Seven	2.20	0.15	1	23.00	3.98	1	N.A.	N.A.

N.A. = not applicable

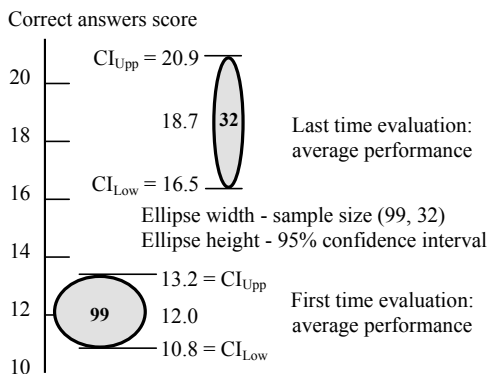


Figure 3. The number of correct answers scores gave by students at initial and final evaluations

Comparison of the average time needed to give a correct answer at the initial and final evaluations revealed that the average time was significantly higher at the final (3.059) evaluation comparing with the initial (1.038) evaluation ($p < 0.0001$, $n_{\text{valid}} = 32$, see also figure 4).

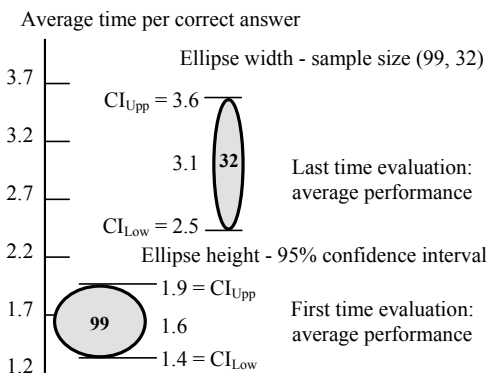


Figure 4. Average time per correct answer score at the initial and final evaluation

DISCUSSION

The evaluation of the students' knowledge is an obligatory task at the end of a course for undergraduate students. The classical essay examination is not the proper type when the class is of ninety-nine students. According with speed, accuracy, objectiveness and fairness [22], testing methods which contains multiple-choice questions are frequently used [23,24].

The developed auto-calibrated online system had advantages and disadvantages. One of the main advantage results from the active implication of the students in creation of multiple-choice banking. This activity motivates students to ask questions and to find answers, implying them into an active learning process and an active interaction with the teacher, processes useful in acquiring materials chemistry knowledge. Another advantage refer the speed of examination: on a class of ninety-nine students, the time needed to assess each essay is significantly greater comparing with the use of auto-calibrated online system. At the end of the examination, according with data stored into database, the system display the correct answers score, and allows to the student to view his/her performances in terms of number of correct answers and average time needed to give a correct answer reported to the results obtained by his/her colleagues. Regarding the objectiveness and fairness, the proposed auto-calibrated online system discourages cheating. On one hand, with a database of eight-hundred sixty-one multiple choice questions is a little bit hard to learn just the questions (note that the randomization process is double: a randomization of the question and a randomization of the options order). On the other hand, the number of distinct tests generated based on the questions stored into database is of C_{861}^{30} which is equal with $2.54 \cdot 10^{55}$, thus the probability that two students to have the same test is very small. The system has its disadvantages. The most important disadvantage is represented by the assessment environment: each student is able to write on a paper but there is no certitude that every student had minimum computers skills. In order to withdraw this disadvantage, the students had the possibility to use the evaluation environment before the examination in order to familiarize with interface, modality of choosing the answer and modality of navigation. With these occasions, the students had also the possibility to assess their knowledge and to identify personal gaps.

Each student had the possibility to test his/her knowledge as many times as desired into the imposed period of time. Twelve out of ninety-nine students performed the evaluation once, being content with obtained performances. Fifty-five students decide to performed the assessment for the second time and the average of correct answers scores was greater with four points comparing with first evaluation (see table II). Analyzing the results in assembly it can be observed that the average of the correct answers score increase with the number of examination (see table II, figure 1 and 2). The greatest difference between correct answers score it can be observed on sample of students which performed the evaluation by three times (see figure 1, std_78) when the difference is of 24.90 points. In the sample of students which performed the evaluation by four times, the greatest difference was of 18.20 points (see figure 2, student id std_13, difference between last and first examination). There were also observed decreasing of performances from the first test to the final test: -0.40 points (see figure 1, student id std_48), respectively -1.40 points (student id std_42, figure 2). With few

exceptions, the students presented to the third or fourth evaluations after they acquired more knowledge on materials chemistry topics with two exceptions: std_48, respectively std_42.

Analyzing the average time per correct answer scores (see table II) it can be observed that the value increase with the number of evaluations. In other word, at first evaluation, the average time per correct answer scores was of 1.64 seconds and increase with evaluations until 3.98 seconds (7th evaluation). The greatest difference was observed between first and second evaluation; the time needed to give a correct answer in the second evaluation was greater with 0.87 seconds comparing with first evaluation. These increases can be explained as follows: the students realized that they need to read more carefully the questions and associated options in order to make de correct chooses.

Comparing the average of correct answers score and respectively the average time needed per correct answer score on the samples of students which performed the test more than two times (see table III), it can be observed that the performances were significantly better (p-value always less than 0.005). Further study are necessary in order to analyze the answer gave by each student to each question, study that can provide useful information about the materials where students had difficulties in understanding and learning. The practical activities, the seminars and the courses on materials chemistry topic could be improved based on obtain information.

On assembly, it can be observed that the performances of students were significantly better at the final evaluation comparing with first evaluation in terms of correct answers score (see figure 3) as well as in terms of average time per correct answer score (see figure 4).

CONCLUSIONS

The proposed auto-calibrated online evaluation system proved to offer a stable and valid evaluation environment of undergraduate students' knowledge assessment on materials chemistry topic.

Students' performances in terms of correct answers score and of average time per correct answer score revealed to be improved at final evaluation comparing with first evaluation, showing an improvement in acquired materials chemistry knowledge.

ACKNOWLEDGMENT

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Development and Evaluation of a Web-Based E-Learning System

L. Schmidt

Research Institute for Communication, Information Processing and Ergonomics
Neuenahrer Straße 20
53343 Wachtberg, Germany

Abstract - In this contribution the development of a web-based e-learning system is described and a method for evaluation is introduced, whereby the e-learning portal INTEGRAL II will be used as an exemplification. The proposed approach is based on system monitoring of user interaction by data capture in a server-log-file, and it additionally integrates external data. As such it is a user-based approach, which typically applies to prototyping or early stages of the product life-cycle. Due to its non-reactive character, the hypothesized biasing effects are supposed to be minimal. Especially server log-files are means of gathering objective, quantitative data which can not be derived by other means. Additionally the procedure is not very complex, that is, it is easy to conduct and does not take too much time to collect data. Log-files are records that are generated by the system automatically and incorporate information about access to and quitting the system, location of the user, time spent with the system and actions within the system. As illustrated in this contribution, these data can be analyzed and interpreted in seven steps. The analysis reveals specific results for the INTEGRAL II system as well as more abstract suggestions for usability testing in general. Log-file analyses in combination with other measures are powerful means of evaluating a web-based system. What information is provided by log-files? What technical framework must be considered for the interpretation? How can these implicit data be used to evaluate web-based systems? These questions are considered in detail in this contribution.

I. INTRODUCTION

The development of a web-based e-learning system and its evaluation by analyzing system-monitoring data of user interactions is proposed in this contribution. The results of the particular work-steps are exemplified in parallel to the introduction of the method by a practical application. The e-learning portal INTEGRAL II, which has been implemented by 15 universities in Germany in order to share e-learning contents related to industrial engineering and ergonomics, is used as an example for a web-based system. Local course offers are supposed to be networked by implementing a platform to which every partner contributes e-learning modules and from which every partner can retrieve contributions from other universities. This platform currently provides 20 modules, which can not only be accessed by the project partners, but also by anyone who may be interested (<http://www.integral2.iaw.rwth-aachen.de>). Besides these modules there are communication features like chat, e-mail, forum discussions and video conferencing. These features can also be used by everyone (students, lecturers, and tutors) in order to communicate regardless of the particular location.

Industrial science is supposed to be supported within different study programs, mainly in engineering, economics and humanities, but also in areas like design, architecture and computer science. The didactical use incorporates multi-medial support for classical forms of education (on-line lecture) as well as self-regulated study activities. To operate the system, a web-server has been installed at the Institute of Industrial Engineering and Ergonomics at RWTH Aachen University, which provides the contents and communication facilities of the e-learning platform. A detailed overview of the platform's features as well as of the particular e-learning modules is given in [1].

II. MAIN QUESTIONS OF THE STUDY

Apart from INTEGRAL II there are several questions to evaluate web-based systems that can be investigated with the method introduced here. Three main questions emerge from observing interactions with the system:

1. From where and how do users get into the system?
2. How is the system used?
3. When and how do users leave the system?

The first question deals with the way of entering the system. The log-file in combination with a DNS look-up reveals indicators for the geographical or institutional origin of the user's request. By interpreting that information it can be investigated whether the intended target group uses the system and the users' structure can be derived. Was the web-address known in advance and did the user directly enter it manually typing the address or using a bookmark? Or was the web site found by using a search engine? If so, the search items can give hints about the individual purpose of the visit. The referrer addresses in the log-file allow determining the navigational origin; so, it becomes explicit from which web site the user entered the system.

The second question refers to how the web-system is used, how long and by whom. How is the percentage of the total amount of users in relation to the amount of user stemming from the target population? After filtering, particular user-groups can be analyzed in detail. Which contents are accessed by which user group and how long are users engaged in working on the material? Do users really use all features or is the access rather selective? Which features are used in what frequency? When and why are help functions consulted? Is it sometimes feasible to increase usability by restructuring the

material? According to preliminary filtering and sessionizing procedures the usage of the system can be evaluated in terms of frequency (amount of visits) and intensity (time per visit, time per page view) to evaluate user acceptance. A relative comparison between users can be made for the evaluation of the statistics that have been derived. Additionally external data can be used for the comparison, like for example statistics regarding other web-based systems. Are typical navigational patterns recognizable? Or do the deviations advise restructuring the system? The semantic coding of the user's interactions is the basis for statements about navigational behavior and the usage of particular contents with regard to its spectrum and time slices. In sum the usage data can be utilized to evaluate user acceptance, derive design specifications, to compare different user-groups and to compare the system with other systems. Design alternatives can be compared and evaluated in the field and in the laboratory, based on actual usage of a web-based system.

Thirdly, the way a person leaves the system can give hints about whether the user attained his individual goal. The success or failure of the system usage might be predicted by how the user exits the system. Possible hints of effective usage of a web-based system could be a good performance on an industrial engineering course. Or is the interaction rather terminated before any usable results could have been obtained? How many sub-steps have been performed? Was it a one-time visit or does the user regularly visit the page? The contingent of one-time versus frequent users is clearly determinable. Is there a relation between system-usage and other external data of the user? The integration of external data allows a statement about interrelationships with the user-status at exiting the system.

III. WORK-STEPS AND THEIR RESULTS

In the following the proposed method is described in more detail by means of seven application steps and their results.

A. Data capture

Web-based systems consist of clients and servers that are not connected constantly, but are rather linked when user interactions ask for it. In a first step of an interaction process a person uses the mouse, the key-pad or another device to enter a specific address of a web-based offer into the browser. After that the client-software construes a request to the server about which object needs to be transferred. Thereby a header and additional information about the software platform, browser, configuration (e.g. language) and if necessary other data (e.g. login data) are being transferred. Based on the request the server chooses the corresponding file or generates it by a script from a data-base. Thereafter the object together with the status code is transferred from the server to the client. The client's browser in turn displays the data and thereby forms the basis for further interaction.

Log-files can be generated by the client and by the server. In the following only the server-log-files will be accounted for,

because they are available to the operator of a web-based system without installing additional software [2].

As the sequence above has pointed out, not the direct observation of the user, but a logging of the client's requests and additional information attached to the transference of data objects are the key factors. This means that certain information does not appear in the server log-file:

- Navigation within a page
- Use of animated contents like Java-Applets
- Software operations like 'print' and 'open in a new window'
- Requests that are not passed on to the server, because they are processed by a local buffer or a proxy-server

Therefore no precise values are possible for the access to content, but rather approximations except for cases in which the access to local buffers or to proxy-servers is prevented (by special design of the page) [3, 4, 5].

The systematic structure of a standard web-server log-file allows recognizing recurring blocks although format and data fields differ in their appearance depending on the particular web-server. The extended log-file format [6] (that is used in this example) begins with a header defining the data fields selected for the protocol. For each of the requested objects a block of data can be found, resulting in very large text files for a specific time period. Particularly the following information is recorded:

- Date and time of the package that has been sent (from server to client, GMT)
- IP-address of the client (receiver of package)
- User-Name if an identification implemented
- Server's site name
- Server's computer name and IP-address
- Transmission-port of the server (e.g.: 80 for HTTP)
- Further specification of the request that has been sent from client to server
- Directory and name of the requested object
- Status-code about failure or success of a request (e.g. 200 for ok; 404 for failure)
- Amount of bytes that has been sent from server to client
- Amount of bytes that has been sent from client to server
- Hostname (sent from client to server)
- Information about web browser and operating system software
- Referrer (specification of the web site that had been visited before, where appropriate including the parameters)

The referrer information is very useful, because it records from where the user originally followed a hyperlink in order to get to the actual page, e.g. which terms have been entered by a user into a search engine before he has clicked on a hyperlink.

A first impression can be read from the amount of blocks in the log-file. Every single record of an object request is also designated as a 'hit'. The amount of hits was initially viewed as a measure of popularity for a specific website. Indeed the amount of hits is not very meaningful, because the transference

status code is not involved. As a result every object request is being counted. Thus, if a webpage for example consists of one text and ten different figures, then eleven hits are counted. Therefore other measures have been established like e.g. page views (also called page impressions). These statistics report the request for the whole web page, not for the particular elements of the page. But, this statistic has to be deduced from the log-file and is only available after editing the log-file.

B. Look-up of the IP-addresses via the domain name service

After data registration in the log-file, the usage of the domain name service (DNS) follows in the next step. The DNS can transfer numerical IP-addresses from the log-file into concrete alphanumeric names. For example the IP-address "131.234.169.104" can be transferred to "café-bohne4.uni-paderborn.de". The name derived from the DNS allows for conclusions regarding the origin of the request. Probably the request originated from an internet café within the University of Paderborn in Germany.

If the log-file is analyzed after look-up of the IP-addresses, the distribution of second level domains can be derived. This result allows an initial evaluation. It can be concluded whether the target population used the web-based platform. For the e-learning system regarded here, at least some universities can be traced back well as the IP-addresses lead to names which can be assigned to specific universities. The log-file that is analyzed in this paper covered 93 days from November to February and 327030 hits. At this point in time the development of the e-learning platform has been finished (no differentiation problems between access for compilation and access for request of contents).

The result reflects the usage of a web-based system in education. The intensive usage of the system in the measurement phase in Aachen, Braunschweig, Paderborn and Kaiserslautern can be traced back to promotion of the portal in conventional lessons. A further analysis of the IP-addresses shows a limited amount of accesses via proxy servers (presumably due to broadband access provided by the particular university). Beside assessment of geographical or institutional origin, accesses via internet service providers like "T-Online" or "AOL" are identifiable which militates for students using the platform at home.

C. Preliminary filtering

Some looked-up IP-addresses provide clues which also indicate pseudo-users, like automatic search engines (spider, robots, and wanderer), e-mail-address collectors or hyperlink checkers which can be filtered out in the next step. This general preliminary filtering also contains disturbing factors (e.g. access to web page resulting in problem report, access to a particular graphics within a page). After that filtering the statements about page views are more accurate (regarding amount and origin of access).

A concrete allocation of the different computers and their corresponding users is not always possible. The IP-addresses are sometimes allocated dynamically (especially with dial-in

and WLAN accesses), due to a limited amount of IP-addresses within a given network. That is, the IP-addresses are allocated to different computers at different points in time (accordingly different IP-addresses allocated to the same computer at different points of time). On the other hand, networked computers that are protected by an internet firewall have the same IP-address outwards (network address translation). Furthermore the same person can use different computers (e.g. at university and at home) or different persons can use the same computer (e.g. from a computer-pool). As a consequence it is not possible to identify the users unambiguously, solely based on web-server log-files.

A solution to the problem would be to use more protocols than just the web-server log-file, like for example the user-login data. User-login was obligatory in the period of data collection for INTEGRAL II and the guest account was closed off. In addition, the protocol for new registries was used (user data-base with registry-data).

D. Sessionizing

The log-file contains particular requests for objects from different clients. Sessionizing comprises the integration of a sequence of requests by a client within one visit. Thus, a visit is a coherent, continuous usage by a client. A visit can be traced back via specific additional information like browser or operating system software or referrer or by tracking a specific time frame. If no request is being made in that time frame, the visit is over (typically 10 minutes). To allocate a session-ID (attached to the web page address) for every single usage would be another possibility.

The statistical data "page views", "visits" and "time per visit" are periodical summaries for the time related usage. A day history shows usage during working hours and spare time or the fact that international users access the page during the night (night in central Europe). In the week-history differential usage during the week and the week-ends is apparent. The year-history clarifies effects of season and long-lasting trends. Time related statistics reveal the influence of external factors like the weather, regional holidays, sport or other events, promotion actions et cetera.

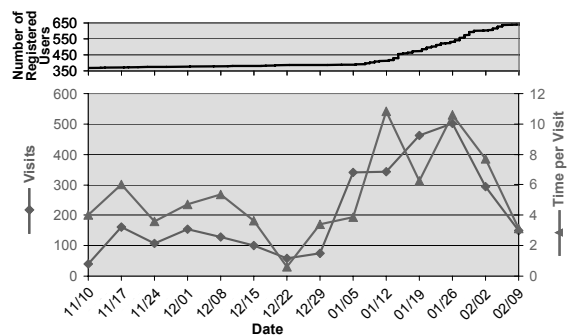


Fig. 1. Usage of the system in different weeks (93 days, 2.916 visits, 112.027 page views)

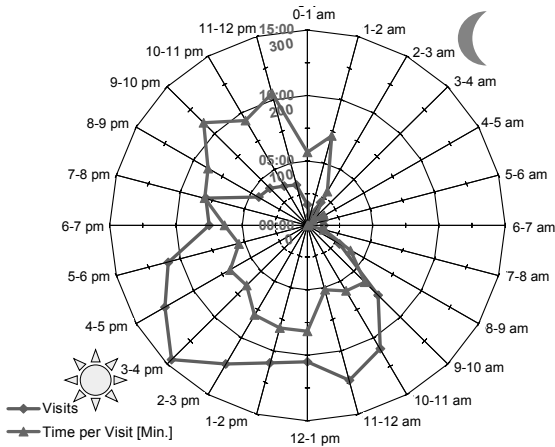


Fig. 2. Usage of the system displayed by time of the day (93 days, 2.916 visits, 112.027 page views)

The total usage of the e-learning platform in relation to time is visualized in Fig. 1 and 2.

The amount of registered users (Fig. 1, top) during the project kept relative constant at about 380 users. After a public relations campaign at the end of December (80 university institutes were addressed) the number of users increased. Actually there are 700 registered users, but possibly most of them are one-time visitors.

A much more differentiated picture is given by the amount of visits per week (Fig. 1, bottom). A decrease in usage is observable during Christmas holiday and an increase after the public relations campaign mentioned above.

If the time per visit is analyzed as a measure for intensity of usage [7], then it has to be stated, that time per visit was very short until mid of January. Many of the new users were engaged in deriving an overview before leaving the platform again. The increase beginning mid of January will be discussed in detail later on.

The usage of the system in relation to the time of the day is derived similarly (Fig. 2). The amount of visits is at its maximum between 3 and 4 p.m. If usage time is taken as measure for intensity, the maximum is reached between 9 p.m. and midnight.

A similar heterogeneous distribution of usage of the e-learning platform is derived by analyzing week-days. A lot of visits are recorded from Monday till Thursday. At the weekends the usage time increases, resulting in a higher intensity of usage during the weekends.

E. Semantic coding and defining categories for evaluation

As it has been described above, log-files contain low-level data of usage. But actions that have been recorded like clicking a graphical element using the mouse may have other intentions in different contexts [8]. For being able to differentiate between various interactions, the pages need to be categorized. These categories depend on the aims of the study, e.g. to

analyze the navigation behavior, and build the basis for further evaluation.

The analysis of navigational behavior can be modeled via a transition diagrams or via decision trees [9]. If letters symbolize categories as states, arrows between them symbolize transitions from one category to the other. For example users may first get an overview by screening category "A" and then some of them choose to read something specific about a particular topic in "C". Some other may be engaged in reading "D". Both of the groups then may go into detail of the desired topic by exploring deeper categories. Typical usage patterns can be derived by adding likelihood values for the transitions between the states of the model. Particular strategies can be derived (searching, browsing, exploring, etc.). The strategy seems to be strongly dependent on the design of the web site (character of hypertext, steepness of the hierarchy, navigational help, and search possibilities).

Looking at semantic categories in regard to the e-learning platform reveals a differentiation between log-in, receptive learning environment, interactive exercises, help function, contact and bookmarking. One research question would be whether different types of learners are identifiable.

Classifications could also be based on the content. The e-learning platform used the following categories:

- 17 thematic learning modules
- 2 cross-sectional categories with methods
- one self-assessment (including old exams)

Interactions that are not attributable to one category (forum-discussions, e-mail, video chat, etc.) are excluded from the analysis. Taken together with usage times the main interests of users can be identified. The categorization needs to be interpreted and therefore can not be automated.

F. Goal-oriented filtering

The goal-oriented filtering is described in the following section. A distinction between four didactical scenarios has been made on the basis of a requirement analysis:

1. Helping lecturers with presentations (e.g. in a conventional lecture)
2. Students working on assignments during a training session
3. Students working on a topic for preparing the exams (independent of time and location)
4. Location- and time-independent processing of complex case studies (e.g. student research project)

The third scenario will be analyzed in detail in terms of e-learning support for deeper level processing and as a preparation for the exam. Furthermore five kinds of users were defined based on the requirement analysis:

1. Students: bachelor's and master's degree
2. Instructors: professors and research assistants
3. Authors: mainly research assistants
4. Administrators: research assistants, student workers, mathematic-technical-staff (apprenticeship in Germany)
5. Guests: prospective users, which can access the web site without registration

It was not sufficient to lock the guest accounts and choose a time interval at the end of the project in order to filter out the students. The different kinds of users could not be allocated unambiguously based on the protocols. The decentralized usage at different locations was so differentiated that controlled conditions were impossible.

Therefore the analysis was conducted at the University of Paderborn. This University was not influenced by the project, that is, there were no authors of the modules as well as no administrators. The issue in question was a basic lecture in industrial engineering that covers the same topics as the INTEGRAL II modules. Approximately 230 students visited the lecture from which 201 signed in for the exam and finally 173 students were actually present in the examination. The university virtually offered access to the system to every student via university resources (WLAN, Computer pools, and dial-in-access).

There is a clear time-frame for usage which begins on January, 16, and ends on January, 30, with the exam. The web-based system INTEGRAL II was unknown to students from Paderborn and there were no users registered before this date. Thus, this population (in the time frame mentioned above) will be analyzed in the following.

The graphs in Fig. 3 clearly show an increase in visits as the written exam gets closer. The mean was 12.8 visits per day. In that period of 15 days, 76 different users could be identified, which visited the page averaged 2.5 times, 28 users visited the page only on one occasion. The amount of page views as a measure of the distribution of the usage fluctuated and increased in the course of the investigation. On the average there were 38 page views per visit and one single page was inspected 25 seconds. The amount of page views strongly correlated with the time per visit, which is also presented in Fig. 3. In summary the frequency and intensity of usage climaxed one day before the exam and then broke down.

The amount of visits was the highest between 10 a.m. and 8 p.m., but students also dealt with the system during the night times (Fig. 4).

Concerning the contents that were requested by students, in total 18 of the 20 modules were used. The usage of the self-assessment incorporated 85 % of total usage time which points

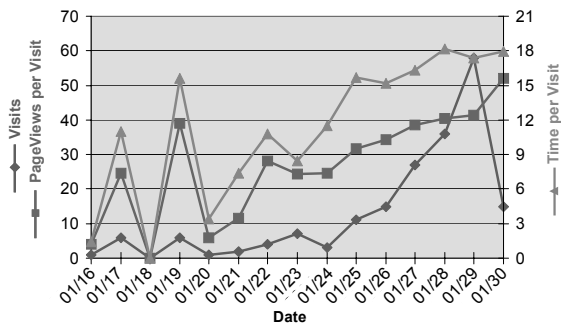


Fig. 3. Usage of the modules by students participating in the written test (15 days, 76 users, 192 visits, 7.319 page views)

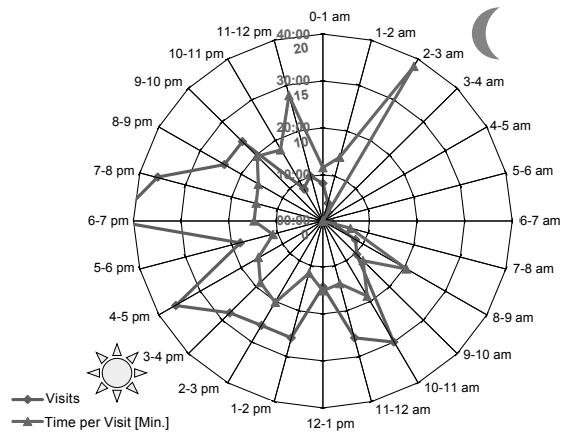


Fig. 4. Usage of the modules by students participating in the written test by time of day (15 days, 76 users, 192 visits, 7.319 page views)

at students preparing for the exam. Augmented reality items (one of the modules) were inspected for 5 hours on the average (10 %) whereby the other modules share the residual 5 %. The focus on the self-test is apparent from these numbers; obviously augmented reality seemed to be most interesting for the students.

G. Integration of external data

In a last step, external data will be integrated in order to pin-down possible interrelationships.

The results of the exams were used for this purpose as external data (Fig. 5). The Kolmogorov-Smirnov test indicated not to reject the assumption of normality ($p = 0.5$). A mean of 23.7 of 60 scores has been reached in the exam ($n = 173$).

In sum 76 subjects used INTEGRAL II which commensurated with 44 % of all possible users. The sample has been split into users and non users (Fig. 6).

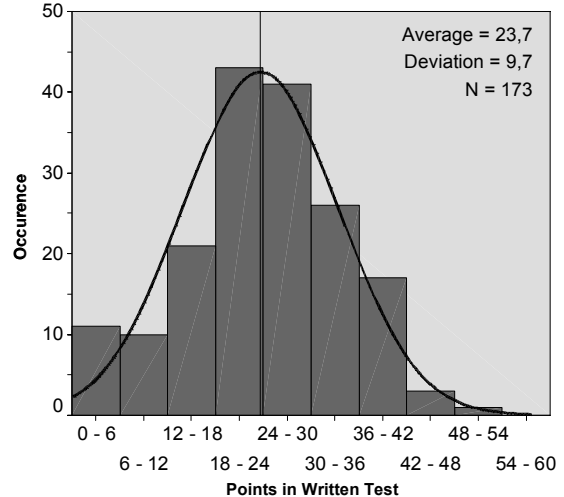


Fig. 5. Results of the exam as external data

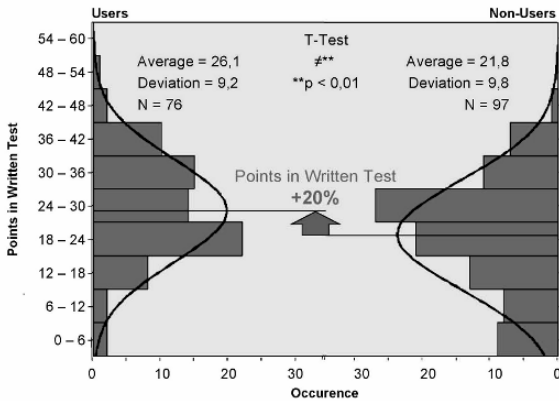


Fig. 6. Result of the exam in relation to usage of the system

Both groups were normally distributed (Kolmogorov-Smirnov test: user $p = 0.59$, non-user $p = 0.45$). The T-Test revealed a significant difference between the means of both groups ($p = 0.004$). The users of the e-learning system achieved 26.1 scores on the average whereas non-users obtained only 21.8 points (difference app. 20 %).

The relationship between usage of INTEGRAL II and success is apparent in the light of the fact, that 4 of the 5 best results in the exams were performed by INTEGRAL II users, whereby 4 of the 5 worst exams were achieved by non-users. The correlation between usage time and scores on the exam was $r = 0.244$ ($p < 0.01$). Thus, there was a tendency to derive better scores if exposed to the system for a longer time.

The total visiting time was approximately 41 minutes per visitor. Five persons used the system longer than 1.5 h and 3 persons even used it longer than 2 h. These prolonged usage times did not reflect a better performance on the exam, but seem to reflect a reduced capability of information processing, because users are either too slow or need to read the information several times.

A quadratic regression revealed an optimal usage time of 73 minutes (60 minutes for test-exam and 13 minutes for orientation and evaluation). Thus, a usage time longer than 73 minutes correlated positively with lower score ($r = 0.313$; $p < 0.001$).

On the average people were busy with each page view for 25 seconds. 7 persons needed longer than 40 seconds, whereby 3 subjects even took longer than one minute. This also correlated with worse performance ($r = -0.305$; $p < 0.01$). Thus, there is a negative correlation between view time and performance.

IV. SUMMARY AND OUTLOOK

Finally these results will be used to answer the evaluative questions that were stated in the beginning.

From where and how do users get into the system? The logfile in combination with the referrer allows determining whether a direct entering of the address, a hyperlink, a bookmark or a search engine referred to the system. The DNS

look-up revealed indicators for the geographical or institutional origin of the request.

How is the e-learning system used? According to the preliminary filtering and the sessionizing procedures the usage of the system can be evaluated in terms of frequency (amount of visits) intensity (time per visit, time per page view). The semantic coding of the interactions creates the basis for statements about navigational behavior and the usage of particular contents with regard to its spectrum and time slices. After goal-oriented filtering, particular user-groups can be analyzed. In sum the usage data can be used to evaluate user acceptance, derive design specifications, to compare different user-groups and to compare the system with other systems.

When and how do users leave the system? The contingent of one-time versus frequent users is clearly determinable. The success or failure of the system usage might be predicted by how the user exits the system. The integration of external data allows statements about interrelationships with the user-status at exiting the system, like it has been shown in the correlations between performance and usage of the system.

Only a brief sketch of the exhaustive possibilities can be presented here, but some ideas about further application can be given. By applying statistical data to the analysis, the results could be used in a feedback loop to individualize the web site based on personal preferences. A combination with other evaluative measures and their corresponding results is useful and application to other areas is thinkable, like for example the automated detection of an epidemic dispersion based upon time series analysis of the access to medical data bases for a particular diagnosis or symptoms.

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PROMOTING ENGINEERING CAREERS USING MODERN SENSORS IN HIGH SCHOOL SCIENCE LABS

Edwin Yu, Magued Iskander, Ph.D., PE, Vikram Kapila, Ph.D., and Noel Kriftcher, Ed.D.
Polytechnic University, Brooklyn, NY 11201

Abstract— A student’s first introduction to engineering and technology is typically through high school science. Unfortunately, science labs often make use of antiquated tools that fail to deliver exciting lab content. As a result, many students are turned off by science, fail to excel on standardized science exams, and do not consider engineering as a career.

This paper reports on the preliminary results of Project RAISE, *Revitalizing Achievement by using Instrumentation in Science Education*. RAISE is a partnership between Polytechnic University and several New York City (NYC) high schools that is funded by the National Science Foundation (NSF). By using sensors and computerized data acquisition in science labs, RAISE seeks to enhance students’ academic achievement; excite them about science, technology, engineering, and math (STEM); and inspire them to pursue STEM careers. A description of the project, along with some of the sensor-based experiments that are in use, are presented along with lessons learned.

I. BACKGROUND

American Universities must recruit, train and graduate large numbers of scientists and engineers in order for the United States to sustain its “innovation economy.” Education for engineering and technology careers has always been considered more rigorous than education for 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. Secondly, society discourages female students from becoming engineers or scientists. Finally, math and science studies are not perceived as 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. Unfortunately, due to limited resources and shortage of adequately trained high school science teachers, schools often present required science courses in an unimaginative manner [1]. They introduce basic scientific concepts in the abstract, and fail to relate these concepts to science, as encountered by students in their daily lives. That is one 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. The result is poor achievement on standardized science exams and apathy about pursuing careers in engineering and technology.

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 [2-4]. In addition, those students who are most proficient in science and math, will be introduced to contemporary innovative ideas which, it is hoped, will make them more likely to be enticed by career paths that are related to science and engineering.

Instrumentation and monitoring was selected as a general theme for this project 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 students with an opportunity to apply their science and math skills; (4) data visualization affords an opportunity to develop students’ cognitive skills and the excitement of self-discovery; (5) through lab activities involving modern sensors, students develop inquiry-based learning skills; (6) data acquisition and

reduction allows us to monitor student learning and identify areas of weakness; (7) since manual collection and recording of data is not the principal focus of the lab, students can focus on learning the underlying concepts of the lab and formulating and testing new hypotheses; and (8) 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 students' leisure-time use of state-of-the-art equipment in comparison to their use of manual equipment in traditional science labs.

II. PROJECT OVERVIEW

High school science and math courses have historically been viewed as the "gatekeeper" to engineering education. Students who excel in these subjects succeed in high school and have the option to continue their education at college in a technical or engineering field. However, the inherent rigor of science and math, the quality that helps impart this gatekeeper function, also presents great challenges to educational systems. A lack of fully prepared science and math teachers, coupled with a well-documented general teacher shortage [5,6] limits the achievement of students in STEM disciplines in American K—12 schools. Without dramatic intervention, these dynamics do not bode well for American engineering colleges being able to fulfill the workforce needs of an innovation economy. These needs are too great to rely on schools of education alone to provide the training and human resources to accomplish this goal. At the very least, the current scenario suggests an important supporting role for engineering colleges in assisting pre-college STEM programs.

The RAISE project, a partnership between Polytechnic University and four New York City high schools, [7] seeks to enhance students' academic achievement in STEM disciplines. This program is funded by an NSF GK-12 Fellows grant. The high schools participating in Year-1 of this program were George Westinghouse, Marta Valle, Seward Park, and Paul Robeson. In Year-2, Seward Park High School was replaced by The High School of Telecommunications, Arts, and Technology. In Year-3, George Westinghouse was subdivided into two schools, George Westinghouse and Ninth Grade Success Academy, both of which were included in the project.

Project Planning

The RAISE Program was developed through a dialog conducted over 18 months between Polytechnic faculty, high school principals, teachers, and school district administrators, culminating in a proposal to NSF. The dialog assessed the STEM curricula and educational, instructional, and teacher training needs of schools.

After initiating the project in summer 2004, monthly meetings were held to discuss: content/time constraints on curriculum, technology training needs of teachers, student

academic preparation, opportunities for curriculum innovation, availability of time in their curriculum to integrate lab activities, etc. Our interactions have resulted in the identification of Forensic Science, Living Environment, Marine Science, Earth Science, Active Physics and Physics as the courses that can benefit from this project, for several reasons. First, through RAISE activities in these courses, students' interest in science and math will be sparked early on and reinvigorated near the end of their high school careers. Secondly, these courses have lab components, which allow ease of RAISE activity scheduling and benefit from the use of modern sensor technology. Thirdly, the curriculum of these courses is a natural fit for integrating sensor-based activities. Finally, the project will synergistically influence performance in Math—A, since math skills will be developed, applied, and practiced in all learning activities.

Project Objective

The project objectives address several common areas of need found in NYC high schools:

- Enhance student achievement in standardized exams in Living Environment, Marine Science, Physics, Active Physics, Earth Science, and Math-A.
- Expose high school students to engineering as a career option through the (1) positive role models, (2) lab experiments that introduce engineering as the application of science, and (3) a recognition of the role of engineering in every day endeavors.
- Excite students about STEM disciplines through real-world science and engineering projects that make extensive use of modern sensors and provide teachers with technology proficiency, qualifications, and resources to integrate project-based learning in STEM curricula.
- Develop human resources by (1) inspiring students to pursue challenging academic work, meet high academic achievement standards, and acquire a passion for STEM disciplines/careers; and (2) enabling RAISE Fellows to develop communication and leadership skills, and a deeper appreciation for STEM disciplines, all of which will prepare them to be role models.
- Strengthen the ties between Polytechnic University and the New York City public school districts.

Project Organization and Training

The RAISE program is supervised by two engineering faculty, and one liberal arts faculty. During the summer, each Fellow is paired with a RAISE teacher attending a weeklong workshop to learn about modern sensing technology. During the academic year, each Fellow spends ten hours a week at their assigned high school as a science resource and five hours a week on campus preparing experiments and materials to be used in the high school classroom. The graduate RAISE Fellows are required to make satisfactory progress in thesis

research. They receive tuition remission for three graduate courses and as well as a stipend, while the undergraduate RAISE Fellows receive a stipend only. An external evaluator evaluates the progress of the program.

The RAISE Fellows attend a weeklong professional development workshop conducted by an education specialist who formerly served the New York City school system as a trainer of teachers. The workshop is designed to enhance the Fellows' pedagogical, communication and presentation skills, and to help them prepare effective lessons. Many Fellows felt that this training program gave them an advantage in the classroom, especially with matters of classroom management, discipline and effective questioning techniques. Fellows learned practical approaches to anticipated challenges that may arise in the classroom and they also developed techniques of conveying academic material in an effective manner.

The RAISE teachers underwent a weeklong training session on how to implement sensors in classrooms, effectively. The teachers also received a crash course in mechatronics and engineering, in which they made their own robots. The rationale behind this training was to encourage and excite the teachers to go beyond basic implementation of sensors in the classroom, and to present an opportunity for the teachers and Fellows to bond with one another. A secondary goal was to motivate some teachers to start robotics clubs at their schools, where they could use what they learned during the training session and motivate students to joining this club.

III. IMPLEMENTATION CHALLENGES

Year-1

The program got off to a slow start in Year-I because of scheduling conflicts and some lack of appropriate equipment. Initially, it was difficult to attract graduate students to join RAISE in a hot job market despite the generous stipend (\$30,000 plus tuition) because jobs and paid internships were plentiful. Out of the twelve Fellows selected for Year-I, ten were undergraduate students. Since undergraduate classes are scheduled mainly during the daytime, this limited undergraduate Fellows' availability to serve in high schools.

A second challenge encountered in Year-1 was that the NSF GK-12 program provides generous stipends but does not allow for adequate equipment funding for the high school. Polytechnic University subsidized the program by providing each school with four biology and four physics sensor kits. However, when Marta Valle was added to the program, it had to share kits with Seward Park High School.

Schools were required to provide laptops. It was difficult for many schools to find funding to meet this requirement, at least in a timely manner. In Year-1, schools that were unable to provide laptops or computers used the sensors with graphing calculators. By Year-2, however, all schools were equipped with laptops or computers.

Despite receiving intensive training, problems were bound to arise during the pilot year of the RAISE program. These ranged from poor classroom discipline to students' inability to cope with new technology. For many students, it was the first time that they were being exposed to such equipment. However, eventually over the course of the year, students formed an appreciation for the sensors and were able to do the many computations that were required of them.

One dramatic contribution in Year-I was the role of Fellows at one of the schools when a teacher suffered a debilitating heart attack. The principal had enough confidence in the Fellows to have them provide instruction for the class in an effort to salvage the class although a replacement physics teacher could not be found. According to the NYC Board of Education rules, a certified teacher must be present in the classroom at all times. A substitute teacher was hired to meet this requirement, since he did not play an active role in teaching the material. This was a noble effort, and although the class eventually had to be disbanded, the Fellows had proven their value through this rescue effort.

Year-2

New York City is in the midst of a major school reform effort, which frequently breaks up large schools into several small ones occupying the same building. Seward Park is one of the schools being phased out. The principal and the assistant principal for science, as well as some science teachers, left to pursue a variety of professional and personal interests. It was difficult, therefore, to maintain Seward Park in the project, under these circumstances.

In the second year, the benefit of RAISE to the Fellows was evident. Five of the ten undergraduate Fellows applied to continue as graduate RAISE Fellows and pursue their studies towards the master's degree. Thus, in Year-II there were eight graduate and five undergraduate Fellows, which made in-school scheduling considerably easier.

Improvements over the pilot year were made. Over the course of the second summer, the Fellows and teachers started planning for the upcoming school year in terms of scheduling, lab experiments, tutoring, and various other activities. The Fellows underwent a second summer workshop similar to the first in order to train them effectively for working in their classrooms. Since most of the Fellows were experienced, they enjoyed a comfort level with their cooperating teachers. This familiarity promoted communication that led to more improvements in the program's infrastructure.

Year-3

The program is now facing similar challenges to those encountered in years I and II. First, many graduated seniors were attracted by the hot job market and chose not to apply for graduate study or to the program. As a result, only three new graduate Fellows joined the program, of which one was returning undergraduate Fellow from year I and two were

returning undergraduate Fellows from year II. Only few senior undergraduate students applied to the program due to their school work load and part time internship opportunities in engineering firms. Therefore, recruitment of RAISE Fellows is focused mainly on undergraduate students who are juniors, which causes some scheduling conflicts.

A second difficulty is that, thanks to the NYC school reform initiative, GWHS has been sub-divided into two schools. One is located on the top floor of the building and the second occupies the rest of the building. Although both schools exist in the same building, there are significant difficulties in moving, storing and sharing equipment.

Finally some high schools are in need of additional computers for data acquisition since the computers originally used for this task were reassigned. Consequently, Polytechnic University donated several used computers to maintain the function of the program.

IV. BROADER IMPACTS OF PROJECT RAISE

A change in students' attitudes was observed over the course of the year. Students generally looked forward to performing lab experiments. The tasks that they may have found daunting in the beginning of the year became second nature. Furthermore, students devised extensions to the lab experiments for a fuller learning experience. Some students started expressing interest in careers in science and engineering to Fellows, whom they looked up to as a source of inspiration, and for career advice.

The RAISE program affected the Fellows as well. Fellows displayed an improvement in their communication and presentation skills. Additionally, many indicated that their own comprehension of scientific principles has improved as a result of having to teach. However, the impact of RAISE extended beyond the classroom, as well. Many events were organized to support program goals. These included:

Career Day

Polytechnic University hosted RAISE Career Day on both April 20, 2005 and May 24, 2006. Students from the four participating high schools were exposed to various disciplines of engineering via presentations and tours made by faculty and recent Polytechnic graduates. The purpose of this event was to arouse students' interest in science, engineering, and technology that may lead them to consider engineering as a possible career option.

NYC NSF GK-12 Grant Holders Meeting

The NYC NSF GK-12 Grant Holders Meeting took place on May 20, 2005. This meeting was hosted at Polytechnic University. Participants included representatives from the four GK-12 projects in NYC: Columbia University (two programs), CUNY Graduate Center and Polytechnic University. The NYC Department of Education played a vital role in ensuring the success of this program. This meeting

provided an opportunity for participants to discuss major challenges that are faced within collaborative programs, which seek to enhance K-12 learning in science and technology. In addition, it gave a chance for the participants of the different GK-12 projects to network and explore new methods of tackling similar problems. The GK-12 program team from NSF also attended this event.

Annual GK-12 Meeting

The Association for the Advancement of Science (AAAS) and the NSF hosted an annual meeting for the GK-12 project teams in Arlington, Virginia on March 4-6, 2005 and March 25-26, 2006. Various GK-12 projects throughout the nation displayed their work, using poster boards and PowerPoint presentations, and gave participants a chance to network and exchange ideas. Polytechnic Fellows were actively involved as presenters.

Third Annual Convergence on Inquiry

On June 11, 2003, RAISE was invited to the Third Annual Convergence on Inquiry at the American Museum of Natural History and gave a presentation to a group of teachers and other educators on how sensors and instrumentation can help students "ask more questions" related to science and technology. The goal of this conference was to discuss different means of getting the students to "inquire."

SMART Program

RAISE Fellows also participated as science resources for Polytechnic's SMART program, at which ten teachers from New York City schools were chosen to undergo intensive training in mechatronics for four weeks during the summer [8]. The Fellows sharpened their own skills in mechatronics and made themselves available to assist teachers in building their respective projects.

V. TYPICAL SENSOR-BASED EXPERIMENTS

Living Environment

Living Environment is a class typically taken in high school by freshmen or sophomores. Students complete the course by sitting for a standardized test organized by the state called the Regents exam. To earn a Regents-endorsed diploma, which is recommended as a minimum achievement for a student entering a college such as Polytechnic University, a student must successfully complete three years of science courses, including passing the living environment Regents exam [9]. For an advanced Regents diploma, a student must pass three Regents exams in science. Living Environment tends to be the student's first exposure to "Regents science" in high school.

The sensor-based experiments that were developed by the RAISE Fellows are modeled after the New York State Living Environment Regents curriculum. They developed experiments incorporating sensors, demonstrating concepts that originally seemed difficult to visualize and comprehend.

The sensors helped students more interactively experience important concepts for the living environment. Table 1 shows twelve Regents Living Environment experiments developed by the RAISE Fellows.

Some of the experiments designed went beyond merely a demonstration of key concepts in living environment. Many of the experiments related everyday life to the content of lab. In one living environment experiment, students were asked to analyze water quality by carrying out four tests: temperature, pH, total dissolved solids, and dissolved oxygen. The students use the corresponding sensors, a dissolved oxygen sensor, a temperature sensor, a conductivity sensor and a pH probe, to perform the tests. Results from each test are multiplied with different weighting factors to obtain a water quality index. Use of sensors enables students to visualize the relationship among the parameters involved the instant results are recorded. Thought-provoking questions are posed to reinforce the concept of water quality testing, such as:

- How do you account for each of the measurements? What, if any, is the relationship among them?
- What can be done to improve the water quality of your sample?

Students investigate their hypothesis and discuss the results with their classmates. Such experiment excites students about the subject, motivates them, and satisfies their curiosity. Next, students are engaged in a discussion of natural resources and laws passed to protect them, such as the Clean Water Act of 1972 and the Safe Drinking Water Act of 1974. This relates science to everyday concerns. The students compare their water quality index to the conventional National Sanitation Foundation Water Quality Index (WQI), which includes nine tests: Temperature, pH, Turbidity, Total dissolved solids, Dissolved oxygen, Biochemical oxygen demand, Phosphates, Nitrates and Fecal Coli-form. This helps students learn how to sort through complex scientific issues and focus on the key parameters.

Physics

Twelve sensor based physics experiments have been developed (Table 2). These experiments are intended to support the Regents Physics Lab. Regents Physics is an elective taken by fewer than 10% of students in the partner schools. The experiments are also used in Active Physics, which is a science course that does not culminate in a Regents examination. Some students take active physics in preparation for Regents physics, but active physics represents the only exposure to physics for 90% of high school students in the partner schools.

These experiments are designed to illustrate some engineering applications while reinforcing basic concepts taught in physics, such as Newton’s laws of motion, friction, and momentum. For example, in the stability experiment, students are first familiarized with the notion of instability in

TABLE 1- Living Environment Experiments

Experiment	Description
Acid Rain	A pH sensor is used to understand the relationship between pH and CO2 concentration of distilled water and how different pH level affects living organisms.
Acid & Base	A pH sensor is used to measure the pH of different liquid that are acidic and basic and help understand the pH scale.
Aerobic Respiration	A CO2 gas sensor is used to measure the rate of respiration. Students compare the different rates of respiration for different energy drinks which help them conclude which drink is the most effective energy drink.
Anaerobic Respiration	A gas pressure sensor is used to measure the rate of respiration. Students compare the different rate of respiration for various energy drinks which help them conclude which energy drink is the most effective
Calorie Content in Food	A temperature probe is used to determine the energy content of a small sample of food. Students learn how energy is given off by food as it burns. They determine and compare the energy contents of different foods.
Conducting Solutions	A conductivity probe is used to measure the conductivity level of different solutions. Students have to understand how the number of ions of solutions relates to conductivity level.
Diffusion	A conductivity probe is used to measure the change in ionic concentrations in a solution over a period of time. Different factors affecting the rate of diffusion were studied.
Enzymes	A colorimeter sensor was used to study the functions of an enzyme present in various detergents.
Greenhouse effect	A temperature probe was used to measure the temperature changes within an environment to understand the greenhouse effect as a physical phenomenon
Monitoring Heart Rate	An EKG sensor was used to graph one’s heart’s electrical activity. Based on the EKG recording the heart rate can be calculated.
Photosynthesis	A carbon dioxide and an oxygen sensor was used to calculate the rate of photosynthesis and compare the affects of light on the rate of photosynthesis
Population Dynamics	A colorimeter was used to monitor a closed population growth of yeast by measuring the turbidity or cloudiness. Photons of light strike the yeast cell and reflect away from the photocell. The colorimeter monitors the light reflected by the photocells as absorbance which is proportional to the yeast present in the medium.

civil engineering structures, in the form of sliding and overturning. Examples of landslides, retaining wall failures, and toppling of cranes and excavators are presented. Next,

students perform an experiment using a force sensor by pulling on a wooden block until the block tips or slides (Fig. 1). Use of force sensor, real-time data acquisition hardware, and real-time data acquisition software running on a laptop computer, allows students to visualize the instance when the applied force exceeds the resisting force, thus initiating sliding or overturning.

Students are then assigned to compute critical forces and compare them with the sensor measurements. This allows students to validate Newton's laws of motion and friction effects. This activity is followed by thought-provoking questions; such as, which face of the block will require the least amount of force to be overturned? Students can 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 students 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.



Fig. 1—Stability test

VI. CLASSROOM IMPLEMENTATION

Usually before performing an experiment, a Fellow will give a demonstration to allow the class a chance to gain familiarity with the lab. Then the students are split into groups of three to five to perform the laboratory activity. Since labs by their nature are interactive, each student is assigned a specific task, such as setting up the experiment, controlling the pace of the experiment, recording data or performing calculations.

Starting in year-2, Fellows set up tutoring sessions to expand their assistance to students who require extra help. Students' receptivity to the Fellows is based on the positive interaction they have experienced, which gives the student an opportunity for a one-on-one learning experience with the Fellow. The presence of another science resource in the class helps alleviate the pressure on the teacher and encourages the students to ask more questions.

TABLE 2- Physics Experiments

Experiment	Description
Air Resistance	An ultrasonic sensor is used to measure the velocity of free falling coffee filter to show that the filter reaches a terminal velocity due to air resistance.
Buoyancy	A force sensor is used to measure the buoyant force of an object immersed in liquid. Knowing the submerged volume, the density of the liquid is obtained.
Conservation of Mechanical Energy	An ultrasonic sensor is used to determine the position and velocity of a tossed ball. The principle of conservation of total energy is verified.
Damped Vibration	An accelerometer is used to find the response of an oscillating mass-spring system from which the damping coefficient and natural frequency is determined.
Electromagnetism	A magnetic field sensor is used to verify properties of a solenoid such as uniform field strength within the core, negligible field outside the core, direction of poles formed due to current direction, and attenuation of field as measured axially.
Freefall Acceleration	Using a photogate, the acceleration due to gravity of a free falling object is measured.
Heat Transfer	Using a temperature probe, the rate of cooling and heating of water is measured. Insulating properties of different materials are also investigated.
Magnetism	A magnetic field sensor is used to quantify the magnetic properties of different materials as well as to classify the materials as diamagnetic, paramagnetic, or ferromagnetic.
Projectile Motion	Two photogates are used to measure the horizontal component of the initial velocity of a ball being rolled off a table. Using this value, the range of the horizontal landing is calculated.
Simple Harmonic Motion	An ultrasonic sensor is used to measure the amplitude and frequency of a mass-spring oscillator. From this, maximum velocity and acceleration are calculated and the mathematical model of harmonic motion is verified.
Stability	A force sensor is used to pull a block until the block tips or slides. The critical forces are then computed theoretically and compared with the sensor measurements.
Static and Kinetic Friction	A force sensor is used to pull on a block, sliding over a frictional surface, to determine the coefficient of static friction. Kinetic friction is determined using an ultrasonic sensor that measures deceleration of the block.

VII. ASSESSMENT

Impact on High School Students

It is difficult to assess the impact of RAISE on student achievement since many of the objectives need time to determine their impact [10]. Nevertheless, most students were excited at the opportunity to use the new instrumentation available in the lab. More students felt that the laboratory component was their favorite aspect of the science course. Teachers believed that concepts learned in sensor-based labs were more memorable to students than those encountered in a traditional lab. Control classes are not available for subjects in all high schools. However, the impact of RAISE is evident where control classes are available. For example comparing Living Environment at George Westinghouse High School, the Mean Regents scores for the RAISE classes was 61.69 compared to 52.92 for non-RAISE classes. Moreover, while 39 of 54 (72%) of the RAISE students took the Regents only 24 of 47 (barely over 50%) took the Regents from the non-RAISE classes. Grades showed similar results: Mean grade for the RAISE students was 66.83 as compared to only 59.56 for the non-RAISE students.

One of the goals of Project RAISE is to encourage high school students to continue their education at a college level in areas related to STEM. There are two problems with assessing this objective. First, none of the students has yet reached college. Secondly, it is difficult to determine if those students who are presently expressing interest in a STEM career would have chosen to study STEM anyway, even without RAISE. Finally, with the many changes associated with NYC school reform, it is difficult to verify the relative contribution of many experiences and initiatives.

All things considered, the project team believes that sensors have had a positive impact on the students' academic experiences. The team also believes that the opportunity for high school students to interact closely with goal-oriented college students who are studying engineering, a rigorous discipline, will help them, to develop academic goals for themselves.

Impact on Fellows

The effect of the program on RAISE Fellows was found to be positive, as evinced by the fact that seven out of twelve Fellows chose to continue the program. Fellows clearly improved their communication and technical skills as a result of frequent presentation of their work. Through classroom management techniques, Fellows polished their leadership and management skills. These elements will serve the Fellows well in the future once they graduate, as they seek to become leaders in their fields.

VIII. CONCLUSIONS

Integrating modern technology into the science lab is an answer to the fading interest in STEM disciplines among American high school students. Students found the labs interesting. Early indications are that students are succeeding on standardized exams in greater numbers than before, and some students are motivated to pursue STEM careers as a result of their exposure to RAISE. The Fellows have improved their technical and pedagogical skills. The RAISE project team strongly believes that, given time, the goals and objectives of the program will be realized, dramatically.

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Our experiences in teaching of digital logic

Krystyna Maria Noga
Marcin Radwanski

Gdynia Maritime University
Poland

Abstract—This paper contains some examples of using Multisim in teaching of digital logic and describes an Internet website containing didactic materials created in the Department of Ship Automation at Gdynia Maritime University. Use of simulation software in education is one of modern training methods. The Multisim 8 software is an easy to use instrument, enabling designing and simulation of electric, electronic or digital circuits and programmable logic devices. Multisim provides large amount of component's database, schematic entry, VHDL/Verilog design entry and simulation.

Presentation of working hardware is the fairest manner of instructing. Rapid development of integrated circuits would require changes in laboratory equipment every year. There are many manufacturers applying different technical solutions, so buying of new devices can be too expensive and unprofitable. Generality of personal computer can facilitate solution of this problem. Easy to use universal simulation software should alleviate expectations of education, if results of simulation are approximated for reality.

I. INTRODUCTION

Within last several years dynamic development of Internet in Poland was implemented to traditional didactic methods. Development of technology has caused huge changes in range of place and manner of instructing. The didactic equipment for digital logic area, which is used by students for research and simulation during laboratory classes in the Department of Ship Automation in Gdynia Maritime University is presented in this paper. Internal local area network connected to Internet has been made to meet requirements of laboratory of digital logic. Student sFTP fileservers and Internet websites <http://www.am.gdynia.pl/~jagat>, <http://rafa.am.gdynia.pl/~czarny> and <http://rafa.am.gdynia.pl/~anacz> are available also, they contain didactic materials. Selected virtual projects prepared with Multisim 8 software, also with the former version, i.e. Electronics Workbench 5.12 and Multisim 2001, languages CUPL or VHDL are discussed [1, 2]. During selection of examples placed in Internet website also were taken into consideration projects of which simulation in Multisim is incorrect.

Digital circuits are important part of electronic or computer control system. Fast changes in technology of logical devices constrains introduction of new elements to the program of laboratory tests. Well known TTL and CMOS integrated circuits are substituted by programmable logic devices (PLD). Hardware description languages (HDL), field programmable gate arrays (FPGA) and complex programmable logic devices (CPLD) are the newest solution in this domain. Chosen education software should enable design and simulation of circuits made in the former and the latest technology.

The students of Marine Electrical Engineering learn hardware and software for control systems, rules of designing and testing of different digital systems. One of the main subjects is Digital Logic, which presents knowledge concerning the fundamentals of designing of digital electronic control systems.

II. Laboratory of Digital Logic

In the Faculty of Marine Electrical Engineering at Gdynia Maritime University, there are two specializations of education: Computer Control Systems and Marine Electro-Automation, where Digital Logic course is realized in the form of lectures, tutorials and laboratories. Students get to know used in practice electronic devices made in classic TTL technology and CMOS technology, programmable devices with hardware description languages CUPL and VHDL.

Students execute a wide range of exercises within the laboratory classes, i.e. synthesis of combinatory and sequence circuits, research in static characteristics of basic gates, designing and testing of switching and arithmetic blocks, research in bistable and monostable flip-flops, integrated counters and registers and time function devices. Besides, they test and carry diagnostics of hoisting winch digital control system. They also realize combinatory and sequence circuits with programmable logic. Before laboratory classes, students should prepare projects, which depend on realized theme. Students execute laboratory exercises using real elements and on other hand in virtual environment of Multisim 8.

The software installed on laboratory server sFTP and HTTP allows students to send reports in the electronic form directly from home, using any kind of Internet connection and next to test projects directly in computer network.

III. THE MULTISIM 8 SOFTWARE

Multisim 8 is a popular electronic design and education software [3]. This program is a complete system design tool, that offers a large amount of components database, schematic entry, full analog and digital SPICE simulation, VHDL and Verilog language design entry and simulation, FPGA / CPLD synthesis,

radio-frequency capabilities. Multisim offers a single, easy-to-use graphical interface for all design and analysis needs.

Virtual measuring instruments present simulation results in graphic mode. Received data can be stored in graphic or text data files. There is a possibility of exporting results to Microsoft Excel or Mathsoft Mathcad software. Multisim 8 offers such instruments as: digital multimeter, function generator, oscilloscope, word generator, logic analyzer, logic converter, Bode plotter, network analyzer, etc. Showing and using of instruments are very close to reality.

Most important advantages of Multisim 8 (education version):

- Tools enabling mathematical processing of received data, creation of tables and diagrams,
- Large library of standard and radio frequency electronic elements and electro-mechanic devices even in cheaper editions,
- Easy to use virtual measuring instruments,
- Hierarchical design for engineering teams with capability of automatic application of changes in project,
- Virtual interconnect bus ameliorates clarity of schematics and reduces number of visible wires,
- Various types of cooperating simulators (SPICE, VHDL and Verilog HDL) integrated in one tool,
- Reliable simulation results.

Most important defects :

- Integrated circuits appearance is not real, inputs and outputs sequence is changed and power pins are omitted,
- Distinct visible transient states during simulation of digital circuits, in most causes invisible and irrelevant in reality,
- There aren't some popular chips in library, i.e. monostable flip-flops 74121, 74123, 4098, 4528,
- Errors in simulation of popular TTL flip-flops, reaction of asynchronous inputs is incorrect,
- Corrupt modeling of asynchronous integrated TTL counters, stimulation of reset inputs does not cause zero state on outputs,
- Very slow simulation of mixed signal circuits.

The features mentioned above indicate distinctly necessity of student's contact with physical parts and circuits. Simulation is not always possible or gives unexpected results. In spite of several defects, Multisim is a good instrument for training. It is possible to introduce wanted elements not included in the library as subcircuits, it has been discussed in the next section of this paper.

IV. EXAMPLES OF SIMULATIONS

Simulation gives an opportunity to test various configurations without fear about damage of expensive parts. It is the best way to prepare students for laboratory sessions. Multisim enables simulation of projects from all sections of digital logic course like logic gates, switching and arithmetic blocks, flip-flops, counters, time function devices, and programmable devices. In further part of this paper there are presented simple

simulations of the circuits, realized in virtual environment, used during digital logic course.

A. Two-Tone Acoustic Generator

Timer 555 is a universal time function device, it can work as monostable or astable multivibrator. There is basic advantage of this device, namely it requires minimal number of external elements for its functioning. In spite of, the fact that timer 555 was designed 30 years ago, it is still often used in different digital systems.

One example of application of timer 555 device is, the two-tone acoustic generator shown in Fig. 1. This circuit consists of two timer 555 modules in astable generator configuration. The first of them is generating acoustic signal at lower frequency which modulates signal generated by the second 555 unit at higher frequency. Values of capacitances C2 and C4 must be properly selected, so generated signal was distinctly audible. The example of output signal is shown in Fig. 2.

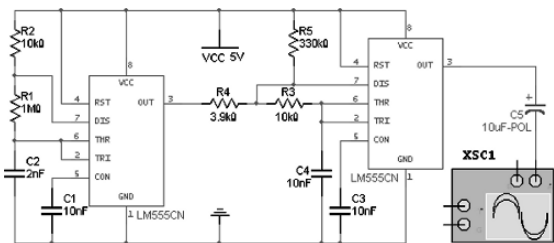


Fig. 1. Two-tone acoustic generator.

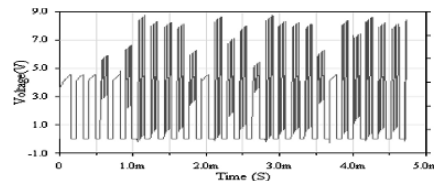


Fig. 2. Output signal of two-tone generator.

B. 4-bit Multiplier by Factor 5

Arithmetic blocks contain such circuits as adders, subtractors, comparators or multipliers. Simple digital circuit, which realizes multiplication of 4-bit, input value by factor 5 is shown in Fig. 3. Input value is applied by set of four manually controlled switches placed as a subcircuit and its logic state is shown on logic indicators. Besides, this circuit contains virtual interconnect bus, which radically reduces number of visible wires. The results are visible on indicators and collected by logic analyzer (Fig. 4).

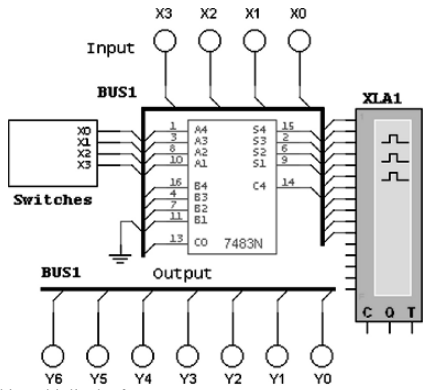


Fig. 3. 4-bit multiplier by factor 5.

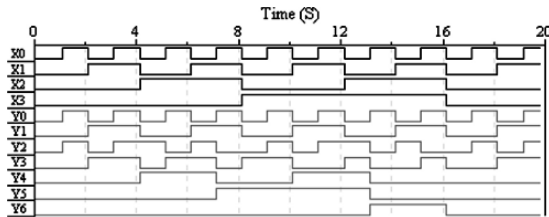


Fig. 4. Time traces of 4-bit multiplier by factor 5.

C. Signal Delaying Circuit

Time function circuits are one of branches of digital logic. This kind of circuits realizes such tasks as: generation of control signals, formatting signals and cutting disturbances, shifting signals in time, and others. Most of the former simulation software bring troubles during simulation of these circuits. The example of circuit delaying negative signal length T by time t_d includes two TTL monostable flip-flops. One of them should be triggered by falling edge of input signal, the second is triggered by rising edge (Fig. 5). The circuit uses two 74121 TTL monostable flip-flops. The TTL 74121 device is not included in education version Multisim 8 library (but included in special version), so internal scheme of this device was created and replaced by subcircuit. The simulation results collected by virtual oscilloscope are shown in Fig. 6.

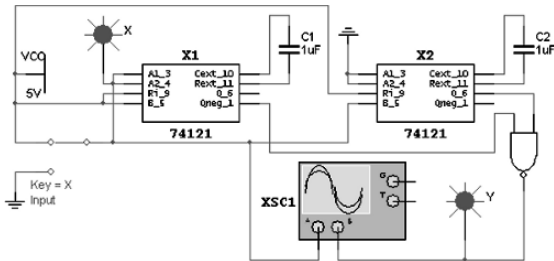


Fig. 5. Signal delaying circuit.

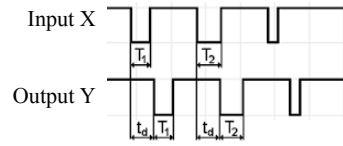


Fig. 6. Simulation results of signal delaying circuit.

D. Integrated Counter Working in Aiken's Code

Integrated digital counters are one of most popular devices used in practice. One of them is 74193 presetable 4-bit binary synchronous up/down counter. Aiken's code is a weighted code, its weight are 2, 4, 2 and 1. A decimal number is represented in 4-bit form and total weight of the four bits = $2 + 4 + 2 + 1 = 9$. Hence the 2421 code represents decimal number 0 to 9. Change of work mode of counter is possible due to utilization of parallel inputs. When counter reaches number 5, value B (equal to 11 in decimal and 5 in Aiken's code) is entered. The entire circuit is shown in Fig. 7. The simulation results are collected by virtual logic analyzer and shown in Fig. 8.

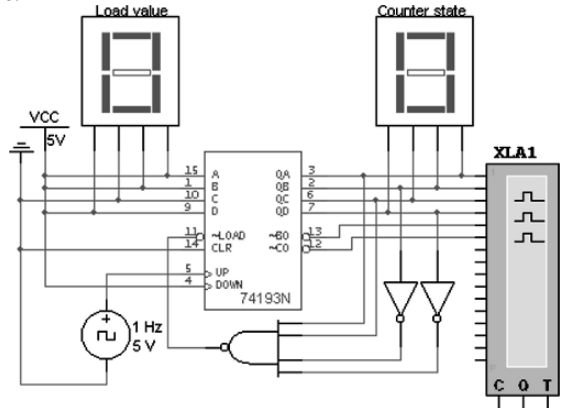


Fig. 7. 74193 binary counter working in Aiken's code.

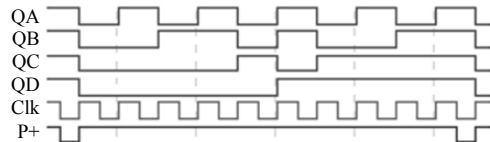


Fig. 8. Signals in counter working in Aiken's code.

E. Morse code generator

Students during laboratory session can also learn different practical codes using in transmission systems, for example code 2 from 5, 3 from 8. They build Morse code generator also. This code was often used in radio telegraphy communication on ships until 1992 year. After introduction of the Global Maritime Distress Safety Systems (GMDSS) the Morse code is used rarely. This code was created by Samuel Morse in 1840.

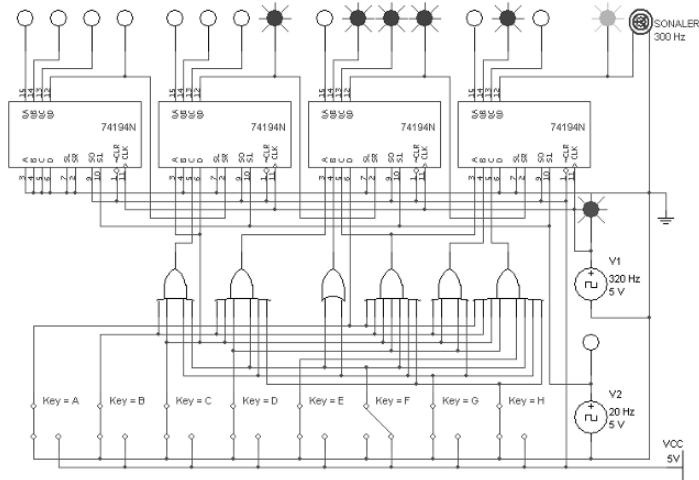


Fig. 9. Morse code generator.

All signs of alphabet are represented by series of short signals (dot) and long signals (lines), for example $\bullet -$, $- \bullet \bullet \bullet$, $- \bullet - \bullet$, $- \bullet \bullet$ denoted properly the letters A, B, C, D. The example of such system is presented in Fig. 9. Complicated construction of such system caused simplification of set of letters (signs) from A to H.

F. Car Lights Control Circuit

Simple practical project of switching block is shown in Fig. 10. It is a car lights control circuit steering direction lights and braking indicators. Circuit consists of integrated flip-flops 74175 (Quad D-type flip flop with clear), different logical gates and is controlled by three simple switches. Outputs represent four car rear lights, their logic states are shown on logic indicators

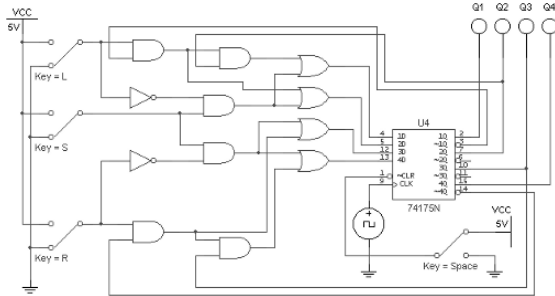


Fig. 10. Car lights control circuit.

V. PROGRAMMABLE LOGIC DEVICES

Multisim VHDL Education is a part of Multisim 8 suite. VHDL module is an advanced tool assigned for training of designing and simulation of programmable logic devices (FPGA & CPLD) and other digital circuits like memory mod-

ules and processors. The program contains ready tools for creating and editing project source code. Most important are: simulator, source code editor, Test Bench Wizard and Design Wizard. Capability of project creation without necessity of previous choice of target device application is the advantage of VHDL [2]. The program offers possibility of determination of VHDL standard (IEEE 1076, IEEE 1164), font and windows display manner.

Basic project structure is created in modules window, which contains program module and simulation module. Besides, it is possible to edit chosen source code of program in edit field or write it independently using VHDL. Simplification for user is distinguishing by program of VHDL keywords (i.e. entity, port, end), which are printed in blue color. Remaining words entered by user are identifiers and they are printed in black color.

Multisim VHDL Education offers ready tools for creation of project. The program makes it possible to choose manner of new project creation at each attempt. The user has to make decision regarding use of automatic creator or manually create blank module.

Multisim VHDL Education is a proper tool for beginners. Extended wizards enable creating projects from basis. Readable editor of code equipped with function of distinguishing VHDL commands and key words (with assistance of color) and simulation window, facilitating debugging and tracking values of variables make designing easier and faster. Multisim VHDL has a lot of simulation options and more advanced wizards, too.

Students realize projects, using programmable devices with not only VHDL language, but also CUPL language. Exemplary projects from Digital Logic, i.e. combinatory and sequence circuits, switching and arithmetic blocks are available on Internet website, described in further part of this paper.

VI. OUR INTERNET WEBSITE

The present development level of Internet enables introduction of new manner of didactic material presentation [1, 2, 4]. Familiarization of students with problems of digital logic is basic task of specially created Internet website available at URL: <http://www.am.gdynia.pl/~jagat>, <http://www.rafa.am.pl/~czarny>, <http://www.rafa.am.pl/~anacz> (in Polish only). To understand the schemes, projects and simulations presented on our website, acquaintance of Polish language is not necessary. Materials placed on these websites facilitate student preparation for laboratory sessions. Students have always access to list of themes of exercises, diagram of occupancy, prescribed literature, instruction book of laboratory, information about fileserver, interesting links and templates of reports. Website <http://www.am.gdynia.pl/~jagat>, created in the Department of Ship Automation at Gdynia Maritime University, is divided into several sections, the most important are:

- Projects section, where big number (over 1700 actually) of projects built with Multisim 8 or Multisim 2001 and Electronics Workbench 5.12 is placed,
- Downloads section, where direct references to all available materials for students are placed,
- "Digital logic" section, divided into subsections: "lecture", "laboratory" and "tutorial", where information and useful materials for individual types of occupancies, projects of counters, working in different codes (synthesis and simulations) are placed,
- PLD section, containing projects created with CUPL or VHDL languages, for example the following projects in VHDL language are presented: up/down counter, adder, 1 of 10 code programmable encoder, code 2 of 5 to Johnson's code translator, start-up of engine control circuit, control of lights on crossroads. Besides, in CUPL language there are presented following projects: drinks selling machine, function generators, heating control unit, various counters, translators and adders,
- Error information tab, where observed software defects in Multisim and Electronics Workbench are listed,
- Full version of "Digital Logic Exam" computer program [1],
- Recent news and materials placed on website,
- Sitemap, containing direct links to all sections on website,
- Information tab regarding use of student fileserver.

Projects available on website were created by students and persons conducting didactic sessions. Materials found on mentioned above websites are often stimulus for making next and modification of existing projects. These materials facilitate apprehension of individual questions and inspire to realization of personal ideas. Examples from daily life are inspiration for creation of projects, too. Students have designed different solutions of such circuits as: traffic lights control, cargo elevator, lift, sport timer, car alarm and various coders, adders, data transmitters and comparators. Exemplary project of car light controller was presented in Fig. 10.

Exemplary simulations of projects are most important part of website. In authors' opinion there is sole website containing so

big number of different kind simulations. Most successful works of students are placed in Internet too, so students and teachers are authors of these projects. Other features like important announcements, notification forms, voting polls and discussion forums make contact much easier.

VII. COMPUTER SOFTWARE "DL EXAM"

Computer Software "Digital Logic Exam" (DL Exam) was created in the Department of Ship Automation and its main feature is possibility of examining students in the form of test with the use of personal computer. This program was created in Borland Delphi 5 environment and with utilization of HTML language. The program works in local area network using Microsoft Network protocol and uses network printers. After start-up of program and filling essential input data, there are shown windows of questions. The rule of evaluating answers is the following: good answer – one point, bad answer – no points. The program enables choice of amount of generated questions, duration of examination, enclosure of additional questions about programmable devices. Actually the program database contains questions from range of combinatory circuits, arithmetic, computational, sequence and time function devices. Sequence of displayed question is generated randomly. The example of generated question by the program is shown in Fig. 11.

During examination the program generates protocol file of all inclusive information concerning student and examination (date and time of beginning, numbers of questions, estimate of individual questions and end rating). The file is generated continuously after every question, so stored data are saved even in case of power loss or other malfunction. The protocol file can be created directly on examiner's computer, so students have no access to it. After the examination is ended the program displays number of earned points and gotten rate.

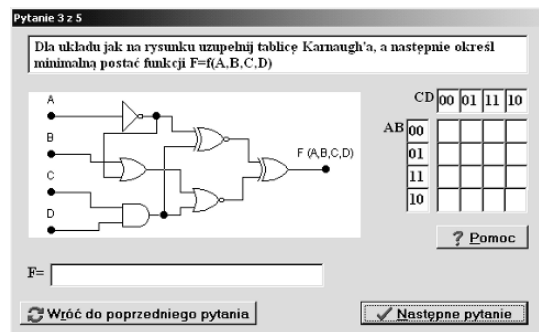


Fig. 11. Example of question concerning logic function of circuit.

In comparison to original version the program includes many changes. The most important are:

- Extended base of questions,
- Capability of manual choice of questions (protected by password),

- Capability of fast start-up of all password protected options,
- Capability of setup of percentage threshold for rates, program stores these settings,
- Password protected option of choice of folder for protocol file,
- Extended help system.

The program is functional and safe, advanced settings like protocol file folder, manual choice of questions, percentage thresholds of rates are protected by password known only by an examiner. The password and parameters are stored in encrypted configuration files. The encryption and decryption process is realized automatically without user's activity. In case of deletion or damage of configuration files the program displays warning and restores default settings. The extended help system created in HTML language, facilitates using new functions. The "DL Exam" computer software is a very useful tool of instructing with the use of computer. This program is also available in Internet.

VIII. ASSESSMENT AND EVALUATION

In comparison to former manner of conducting of laboratory classes relying on circuit montage from physically existing devices, computer simulation enables designing and testing of considerably more circuits in same time.

Evaluating of student's work formerly relied on checking of operation of built circuit and verification of project report written on paper. This is not convenient neither fast method of verification of work of students, in case of extramural studies particularly. Valuation of computer files uploaded on server by students is considerably easier and faster.

Students opinions in relation to new manner of conduction of classes are very positive. Placing of most interesting projects on internet website allows to make library of model examples, it encourages students for designing of effective circuits too.

Interactive website containing message forms, opinion polls and discussion forum allows simple and fast contact with educators. Capability of remote booking of project themes is one of most recent features on website. Rapid development of web technologies promotes moving of educational tasks into web environment.

IX. CONCLUSIONS

Electrical engineer should be prepared for rapid changes in technology. New technical solutions emerge all the time, changes are visible even during study period. Teachers should awake student's curiosity, imagination and creativeness to carry on with latest technology. Easy to use design and simulation software with friendly interface and graphical result presentation gives opportunity to create interesting didactic examples.

Education is the best application of Multisim 8. Maybe its powers do not suffice enough for applying in industry, but it is ideal for training. Honest results of simulation of circuits built

from basic elements could be good introduction into professional design. From the point of view of differences in structure of programmable devices, utilization of software supplied by manufacturer gives better results. For example, free Altera Max+Plus Baseline or Xilinx WebPack are specialized software for circuit design in programmable devices, also used during digital logic laboratory sessions.

Digital logic is a branch of technology, which requires appropriate theoretical and practical knowledge. Didactic materials available in Internet facilitate understanding not only theory but practical rules of construction and design, too. Students have to test their theoretical knowledge, so in this case laboratory sessions are necessary. During these sessions students realize earlier prepared own projects in virtual and physical environment. The mentioned above projects could be practically useful. Students design simulators of practical equipment like automatic washer or microwave, too. Didactic materials presented on discussed website perfectly facilitate preparation of personal student's projects.

The mentioned websites contain many interesting projects prepared among other things by students during laboratory classes. Across these projects it is possible to exchange experiences among students and well-comprehended rivalry, what permits on usage activating methods of teaching.

Today Internet is the most popular communication service for many people, not only for young people. Internet enables contact between teachers and students. Big amount of additional didactic material, which may be placed on website helps to find new training ideas.

Today many education centers offer on-line studies. Rivalry about student on educational market causes appearing large number of richer offers. These proposals are interesting for persons, who choose instructing through Internet from different reasons. Unfortunately, high charges are important factor in Polish conditions in further development of Internet and e-learning. Besides, future will exert efficiency of this kind of instructing.

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Integrated Contact- and E-learning Course in Managerial Psychology for Engineering Students

Jüri Ilvest Jr.
PE Consult Ltd., Estonia
jyrjir@pekosult.ee

Mare Teichmann
Tallinn University of Technology, Estonia

Abstract: In the current paper we share our six years of experience and examine an integrated contact- and e-learning course in managerial psychology for engineering students. To better understand the effectiveness of combining various didactic methods, including e-learning, the engineering students' (N=796) feedback on the course was analyzed. Our study focuses on the face-to-face lecture and the e-lecture, employing either the digital teaching tools on CD-ROMs or web-based e-lectures. We failed to find any statistically significant difference between these two types of lectures in the students' assessment. The analysis of the feedback suggests that the engineering students generally have a highly positive attitude towards integrating contact- and e-learning courses. The findings indicate that successful e-learning takes place within a complex system involving various didactical methods of teaching.

I. INTRODUCTION

E-learning

E-learning is used as an umbrella term to refer to computer-enhanced learning. It may include the use of web-based teaching materials and hypermedia in general, multimedia CD-ROMs or web sites, discussion boards, e-mailing, computer aided assessments, simulations, games etc, with possibly a combination of various methods. Especially in higher education, there is an increasing tendency towards employing e-learning - the explosive rate of growth, now about 25 per cent a year, has made e-learning one of the most popular and widely used learning methods in universities worldwide. By 2003, more than 1.9 million students were participating in online learning at institutions of higher education in the USA according to a report of the Sloan Consortium [22], an authoritative source of information about online higher education. It is a common understanding [7, 23] that the advantages of e-learning include flexibility and greater adaptability to the learner's needs. On the other hand, the most often listed critical disadvantage of e-learning is lack of human interaction as the lecturer is cut out from the teaching process.

Lecture and e-lecture

A lecture is an oral presentation given, for example, by an academic aimed at teaching students a particular subject. It has been maintained and also supported by prominent researchers

[3, 4] that such a didactic method as lecturing is not the most effective teaching method. Though lectures are much criticized, universities have not yet found practical alternative teaching methods for the large majority of their courses. Lectures are used to convey critical information, history, background, theories and equations. Many authors have noted that the method of lecturing is justified if the objective is to present a difficult to obtain or difficult to systematise material to large groups of students [4, 5]. Critics point out that lecturing is mainly a method of one-way communication that does not involve significant audience participation. Therefore, Bligh argues [2] that lecturing "represent a conception of education in which teachers who know give knowledge to students who do not and are therefore supposed to have nothing worth contributing." Based on his review of numerous studies, he concludes that lecturing is not more effective or less effective than any other teaching method intended for disseminating information.

The e-lecture is a lecture delivered via electronic mail to networked individual computers. Usually, the lecturer stands in a room and gives information relevant to the lecture's content. In case of the e-lecture, we move the ordinary lecturing situation to the web environment simulating a real face-to-face lecture as naturally as possible.

The digital teaching tool can be an interactive course module or an interactive part of a course containing pictures, videos, animations or discussion boards. In our course, the digital teaching tool was a special unit of a specific topic and included e-lectures (video-based lectures); the slides used during the lectures and teaching materials for students were also added to the tool. Each digital teaching tool was saved on a CD-ROM; it covered a specific topic of the course. On the other hand, each unit of the digital teaching tools was a part of a managerial psychology course as well. In 2000, we decided that it was an appropriate name for our work because it was a material object (CD-ROMs) as well as a tool for digital or virtual teaching.

In the very first year of this century, we did not know much about the positive or negative outcomes of e-learning. There was already some expertise at Massachusetts Institute of Technology and the first attempts at introducing such teaching tools were made at several European universities, but there was no really serious research in the method itself. Moreover, there was not much knowledge about how to adapt pedagogical and

especially didactic methods to e-learning, or expertise in effectiveness of e-learning.

From the theoretical perspective based on the knowledge of research in human-computer interaction we predict for several reasons that at least three negative aspects of e-learning can occur. First, e-learning as a teaching method is very new and students have no experience in using it; also, it can create even some confusion among students. Second, e-learning is impersonal and, in addition, it has the common shortcomings of the lecture such as one-way communication with the student. However, human interaction can be encouraged and imitated by means of virtual, video-based digital teaching tools and it can be no worse than a face-to-face lecture for a large audience where a single student is also rather passive and communication with the lecturer is one-way communication, too. Third, we predict students to have lower self-motivation.

II. RESULTS

In the current report, we describe six years of our experience and examine the findings of research in student (N=796) feedback on managerial psychology course for engineering students involving various didactic methods, including e-learning.

A. Method. The managerial psychology course was specially designed for engineering students and the course content falls within the framework of the European Curriculum in W/O Psychology Reference Model [6], accepted by the European Federation of Psychologist's Associations (EFPA). In various master and doctoral level engineering programmes taught at Tallinn University of Technology (TUT), the course in managerial psychology is an elective of 2.5 credit points according to the Educational Credit Transfer System (the ECTS). According to the international standards, the standard unit is one week of studies (the study load) of 40 hours which is an equivalent of 10-15 contact hours for lectures and seminars, 15-20 contact hours for skills training, and the rest is students' individual work outside the classroom. The 40-hour week unit relates to the ECTS unit as follows: one unit is an equivalent of 1.5 CP (ECTS).

In September 2000, we introduced our first post-graduate integrated contact- and e-learning course in managerial psychology at Tallinn University of Technology (TUT). For the purpose we created computer-based digital teaching tools on CD-ROM with video-based lectures, the slides showed during the lecture and some written material for student reading. Our first digital teaching tool was an e-lecture „Stress at Work“ (30 minutes long) [14] – the lecture addressed topics such as the theoretical background of stress at work, stressors at work, occupational risk groups and the results of research done in Estonia etc. This digital teaching tool was produced in co-operation with the Estonian National Television Company and all digital teaching tools were financed by a private company, PE Consult Ltd. Within six months, we made seven digital teaching tools on various topics of managerial psychology: „Delegation“ [10], „Managers' Image“ [11], „Teamwork“ [12], „Change Management“ [13], „Customer-friendly Service and Psychology“ [14], „Knowledge

Management“ [16]. The next year, another digital teaching tool was introduced for the course - „Coping with Stress“ [17]; in 2003, four e-lectures - „Motivation“ [18], „Thinking“ [19], „Personality“ [20] and „Conflict Management“ [21] - were added constituting virtual chapters of the basic level psychology book „Digital ABC-book“.

Within the first two years, two parallel ways of teaching and studying were employed for half of the lectures of the course – traditional contact-lectures that have always been used at university as well as alternative e-lectures for the students who preferred studying by using the digital teaching tools. So, half of the lectures of the managerial psychology course provided two options for students: face-to-face lectures at university or e-lectures on the PC (the digital teaching tools). Simultaneously we started employing also other e-learning methods such as web-based teaching materials, student paper and case study analyses via e-mail and teacher-student consultations via e-mail. Seminars, video-trainings, simulations/role plays, discussion meetings, student presentations with video feedback and analysis take place during contact-learning hours (Fig. 1).

At this time, we could not use the Internet because it was too slow for transferring audio/video lectures to PC users and, thus, we chose CD-ROMs. Since high-speed, broadband Internet connections have become a norm since 2003, all eight digital teaching tools are available free of charge for all users via the Internet (www.pekonsult.ee).

B. Student survey. We started compiling a database and analysing students' academic efficiency as well as students' feedback on integrated contact- and e-learning employing various didactic methods. The results based on the managerial psychology course suggest that the engineering students (N=796) generally display highly positive attitudes towards e-learning. However, we were very surprised to find that in the first year when the option to choose either contact- or e-learning was available, more than half of the students (57%) chose both options, i.e. they attended the face-to-face lectures and later watched the same lecture on a CD-ROM. Some students (24%) organised joint viewings of e-lectures in the campus dormitories. In the second year the number of students attending face-to face lectures and watching the same e-lectures decreased to 12%. When asked about such an irrational way of behaving they replied that it was interesting and they were not sure whether e-lectures had the same content as face-to-face lectures. This convinced us to make the digital teaching tools available in the Internet and discontinue parallel face-to-face lectures on the above topics.

The feedback received from the engineering students on face-to-face lectures and e-lectures employing the digital teaching tools or the Internet were computed every year. Since the size of the engineering students sample varied a lot – for example, 55 students in 2000 and 156 students in 2003 - the feedback was constantly positive in case of both methods. We did not find statistically significant difference in feedback on face-to-face and e-lecture methods – e-lectures received as positive feedback as face-to-face lectures.

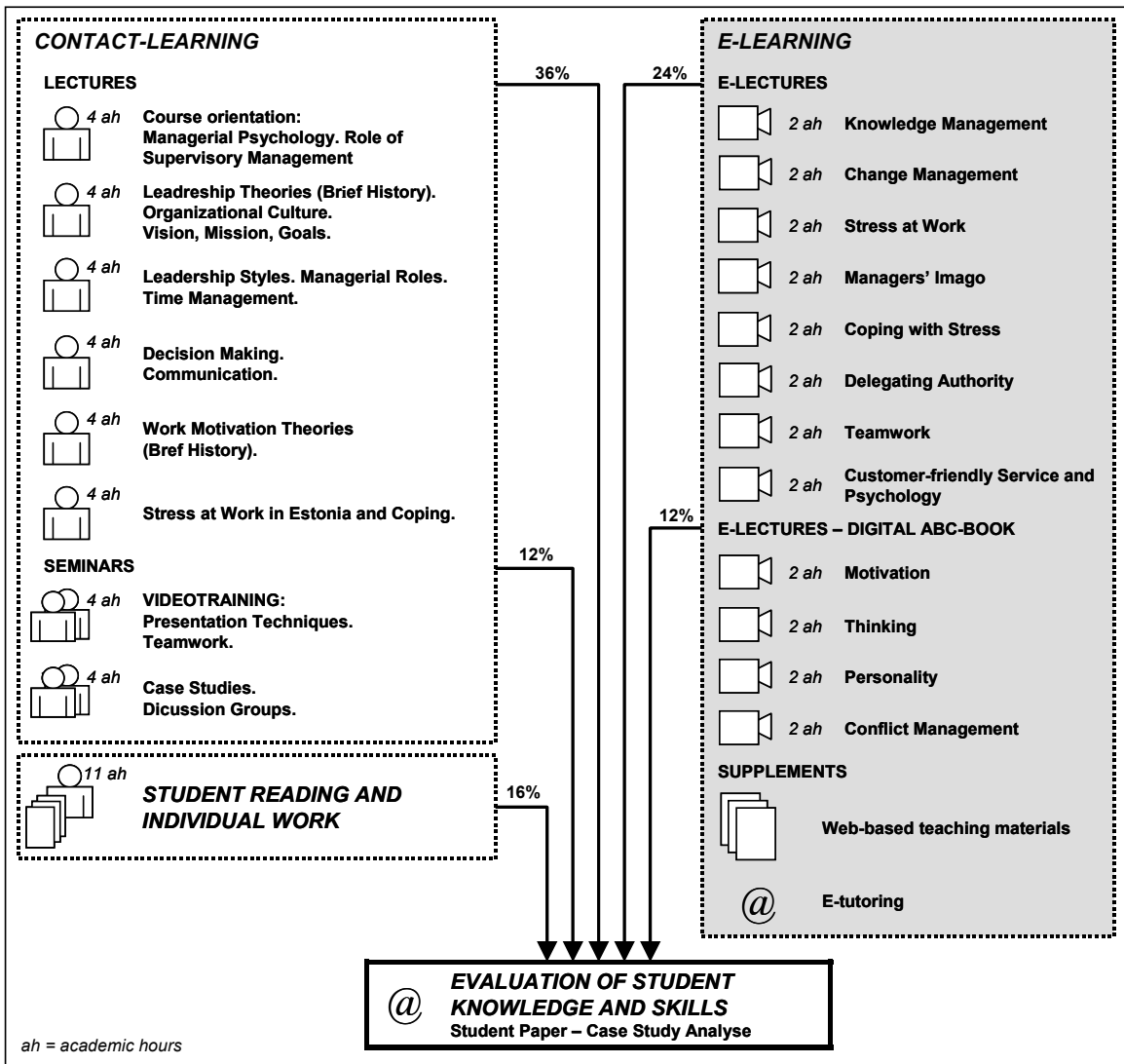


Fig.1 Integrated contact- and e-learning course in managerial psychology for engineering students

First, the possibility to receive assistance not once a week at university at the time determined by the academic but virtually as soon as the problem occurs was listed as a positive characteristic of e-learning. Second, the students were of the opinion that e-learning enabled them manage their time better and take e-lectures whenever it was suitable for them, e.g. at weekends or late at night. Third, the students emphasised independence of location as they could benefit from e-learning also outside the university, for example at work or while abroad. Fourth, the students could re-watch e-lectures while preparing for the examination. The students mentioned the feeling of isolation and the need to motivate themselves to

study as negative aspects of e-learning. As already noted, our third prediction concerned students' lower self-motivation; therefore, we started combining and integrating e-lectures more with contact-learning so that each seminar or practice required the knowledge and material provided in e-lectures. For example, the teamwork video training required the knowledge provided in the e-lecture on teamwork. It has to be emphasised that not once did students mention impersonal interaction with the lecturer in their feedback. Moreover, the students claimed that the academic was familiar to them and the e-lectures caused no confusion.

In a nutshell, the integrated contact- and e-learning course in managerial psychology shows the signs of increasing popularity among the post-graduate engineering students (Fig. 2). The lower number of students choosing the course within the previous two years is caused by the fact that some of the students, who did their master's degree and continued their studies at the doctoral level, already took the course during their master's studies.

Today, we are of the opinion that the following proportion of integrating contact- and e-learning is the most effective (Fig. 1): 24 academic hours (36%) of face-to face lectures at university, 24 academic hours (24% + 12%) of web-based e-lectures (eight digital teaching tools and four e-lectures or virtual chapters from the „Digital ABC-book“ in basic psychology), 8 academic hours (12%) of seminars (video-trainings, case studies, discussion meetings, student presentations, etc) and 11 academic hours (16%) of individual student reading and individual work on papers (two case studies in managerial psychology based on everyday life and analyses of the cases) with the benefits of traditional feedback from the tutor via e-mailing or e-tutoring.

III. CONCLUSIONS

As noted, we tested various didactic methods in integrated contact- and e-learning course in the managerial psychology for engineering students during six years. We examined whether or not the employed didactic methods were successful in the teaching process of the engineering students.

In summary, the popularity of the course among engineering students has increased year by year, the students' academic achievement is good and student feedback on the course is highly positive. The students mentioned better time management and independence of location (there is no need to sit in a university lecture hall to attend lectures) as positive characteristics of e-lectures.

We failed to establish statistically significant differences in student feedback between face-to-face lectures and e-lectures, employing either the digital teaching tools or web-based e-lectures. We can draw two conclusions based on the findings. First, the e-lectures were, in general, well integrated into the course; second, as the face-to-face lectures did not receive more positive feedback, there is not much difference between using one or another lecture method to disseminate knowledge.

Focusing on the common disadvantages of the lecture as a didactic method, no negative influence of impersonal interaction with the academic was found in case of the e-lecture. Moreover, the students claimed that they knew the academic from previous face-to-face lectures and, thus, e-lectures caused no confusion.

The feeling of isolation experienced by the students during e-learning is also often mentioned as a disadvantage of the e-lecture, although face-to-face lectures, discussion groups, teamwork and video-trainings in contact-learning, as well as web-based communication can, in fact, help relieve the feeling and can often encourage students to attend face-to-face lectures and seminars.

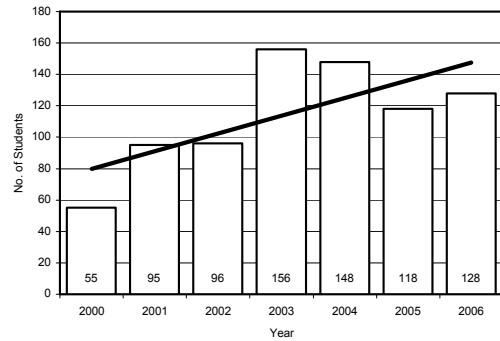


Fig. 2 Number of engineering students in managerial psychology course

As to the students' lower self-motivation while using the e-learning option, it can be improved by combining and integrating e-lectures more with contact-learning so that each seminar or practice requires the knowledge and material provided in e-lectures.

The principal failure of the lecture as a didactic method is one-way communication that does not involve significant audience participation. We tried to compensate for the failure by introducing e-tutoring and incorporating various participative learning methods in the lecture such as rhetoric questions, self-test questions and examples of managerial practice from everyday life that all require cogitating and analysing etc.

We have to agree with Christian-Carter [1, 8, 9] that successful e-learning takes place within a complex system involving other didactical methods of teaching.

Finally, we have a dream after working six years on a specific integrated contact- and e-learning course – collective and co-operative production of a Unified Knowledge Field in the Internet for sharing and „importing“ knowledge and excellence in specific subjects of engineering. The user of the Unified Knowledge Field would not be dependent on location and time. This would ensure that lectures at the highest possible level, for example, in managerial psychology, are available to students at universities all over the world, and help harmonise and improve knowledge in many countries. Today our dream seems possible – we have the technical tools and experience of using them; we have the brains, expertise, knowledge and excellence.

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Engineers' Occupational Stress and Stress Prevention System: E-psycho-diagnostics and E-learning

Mare Teichmann
Tallinn University of Technology, Estonia
mare@pekonsult.ee

Jüri Ilvest Jr.
PE Consult Ltd., Estonia

Abstract: The present research focuses on engineers' occupational stress through the sources of pressure in their job and includes quality of life with the purpose of demonstrating how these pressures affect engineers' quality of life. The main sources of occupational stress in engineers' job were high workload, home-work imbalance and the need to take personal responsibility. The relation of the sources of occupational stress with engineers' quality of life was consistent being negative, yet moderate or low. In the quality of life domains, the strongest relations were between the sources of occupational stress and engineers' physical health and psychological well-being. After these findings we created Engineers' Occupational Stress Prevention System including engineers' occupational stress E-psycho-diagnostics and E-learning.

I. INTRODUCTION

A. Occupational Stress

In the European Union (the EU), work-related stress has been consistently identified over the past decade as one of the major workplace concerns - a challenge not only to the health of working people but also to the healthiness of their organizations. Work-related stress is conditioned by, and contributes to, major environmental, economic and health problems. It affects at least 40 million workers in the 15 EU Member States and costs at least EUR 20 billion annually [12]. The human and financial cost of occupational stress to business and industry is increasing. In the UK, over 10% of the gross national product (GNP) is spent on solving stress-related medical and socio-economic problems. [5]. It contributes to a cost of human suffering, disease and death. It also causes very considerable disturbances in terms of productivity and competitiveness. And much of all this is highly likely to be preventable. A growing body of empirical evidence shows that in Eastern European countries occupational stress level is even higher than in Western Europe and the US [16, 17, 18, 19, 20, 21, 22].

The starting-point of the current paper should be to provide a clear, coherent and precise definition of occupational stress. Prominent researchers have found that this is not as straightforward as that [7, 11]. The ongoing debate about the meaning and definition of occupational stress shows that the academic community has still not adopted a common position. The stressors and strain approach is the core of the majority of recent research into occupational stress. The stressors and

strain approach is based on a relatively simplistic theory that views stress as occurring when work characteristics contribute to poor psychological or physical health [4]. According to this approach, stressors refer to the work-related characteristics, events or situations that give rise to stress, and strain refers to the employee's psychological or physiological response to stress. The main interest, however, focuses on the presumed causal relationship between stressors and strain. The corresponding stressors and strain approach was created as a generally accepted definition in the EU, while the work-related stress was defined as „the emotional, cognitive, behavioural and physiological reaction to aversive and noxious of work, work environments and work organizations. It is a state characterized by high levels of arousal and distress and often by feelings of not coping“ [12].

B. Engineers' Occupational Stressors

The most commonly named occupational stressors are workload, relationships, home-work balance, managerial role, personal responsibility, hassles, recognition and organizational climate. Of course, the studies revealed both similarities and differences in stressors reported across occupations. Interpersonal conflict, work overload and time wasters were common across most occupations. Work overload was reported as a major stressor by many occupations, including engineers [2, 14]. However, according to engineers' occupational stress research, one of the most important job stressors is the need to co-ordinate the work of their subordinates so that the latter would discharge their responsibilities efficiently [3].

C. Quality of Life

Already two decades ago, an important question was raised: to what extent are perceptions of stress and determinants of life quality related? Recent research shows clearly that occupational stress represents a real threat to quality of life for employees [1, 8, 9, 10]. The World Health Organization defines quality of life as the individual's perception of their position in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns [24]. Quality of life (QOL) is a broad concept affected in a complex way by the person's physical state, psychological state, spirituality, social relationships, level of independence, and their relationship to salient features of their environment. Traditionally, researchers have measured quality of life by using the WHOQOL-100 instrument in health related situations. Extremely rare are studies focusing on one or other specific occupational group [6, 13, 15].

The present research focuses on engineers' occupational stress through the sources of pressure in their job and includes quality of life with the purpose of demonstrating how these pressures affect engineers' quality of life.

II. METHOD

A. Participants and Procedure

1) *Sample 1.* The data on the engineers was collected in Estonia from September to December 2005. The engineers (N=229) were randomly selected from different organizations with the help of the Association of Estonian Engineer, and from various industrial undertakings. This occupational sample had an average age of 35.3 years (SD=12.35); 171 participants were males (75%) and 58 were females (25%). Their educational level was: primary education 0.4%, secondary school 2.2%, vocational education 4.4%, master's degree 93.0%. Their marital status was: single 25.8%, married and cohabiting 66.4%, separated and divorced 6.6%, widowed 1.3%.

2) *Sample 2.* The data was collected in 2005 – 2006. The data were obtained from four different occupational groups (N=1005): managers (N=309), civil servants (N=392), lawyers (N=103) and skilled workers from the electronics industry (N=201). In this sample, the average age was 38.33 years (SD=10.77), males 47.9% and females 52.1%. Their educational level was: primary education 0.1%, secondary school 8.1%, vocational education 10.2%, master's degree 81.6%. Their marital status was: single 19.7%, married and cohabiting 72.4%, separated and divorced 6.4%, widowed 1.6%.

All participants completed the questionnaire voluntarily and without compensation. The return rate of the survey was 100% because all participants were interested in personal feedback.

There were some significant differences between samples. The size of the engineers' sample was smaller, their educational level was higher and they were younger.

B. Instruments and Measures

1) *Occupational Stress Indicator – 2 (OSI-2).* For the purposes of this study, we used only eight OSI-2 measures of sources of pressure in job. All of the scales were responded to on a 6-point Likert-type scale. The anchors were (1 point) "very definitely is not a source of pressure in my job" and (6 points) "very definitely is a source of pressure in my job". The reliability of OSI-2 has been reported about in various Collaborative International Study of Managerial Stress (CISMS) publications [18, 19].

2) *WHO Quality of Life Instrument (WHOQOL-100).* Therefore, we also used the quality of life research instrument (the WHOQOL-100 questionnaire), cross-culturally developed by the World Health Organization [24]. The total of 96 WHOQOL-100 questionnaire items was employed. The WHOQOL-100 questionnaire produces scores related to the following six broad quality of life domains: physical health, psychological well-being, level of independence, social relationships, environment and spirituality/personal beliefs. As a result, it produces an index representing the overall quality of

life (the WHOQOL Index). Each domain has several subscales. Four items were included for each subscale. All items were rated on a five-point scale (1-5), but the choices varied across the items. In the WHOQOL Index and in all six domains, the high scores represent higher quality of life whereas low scores represent lower quality of life. WHOQOL-100 reliability has been tested and reported about in previous publications [23].

Additional questions on demographic parameters were added.

The data analyses employed various standard techniques including frequency distributions, means, ranges, standard deviations and significance tests such as Chi Square and t-Test. A statistical analysis was conducted using the SPSS software program. The significance of correlations was calculated by using the two-tailed t-test. The paired t-test was used to assess the differences between specific parameters.

III. RESULTS

A. Engineer's Occupational Stress Research

To test engineers' occupational stress, we calculated the mean scores of the following eight job stressors: workload (PW), relationships (PR), home/work balance (PH), managerial role (PM), personal responsibility (PP), hassles (PD), recognition (PC) and organizational climate (PO). For comparison of occupational samples, we estimated the mean scores of eight sources of pressure in job. In addition, we took Sample 2 (other occupational groups) as a standard and compared it with the corresponding scores of each source of pressure in engineers' job to establish whether there were significant differences (see Table 1).

All sources of occupational stress were higher in the engineers' sample as follows (in the decreasing order): home-work balance, personal responsibility, workload, recognition, organization climate, managerial role, relationships. There were significant differences between occupational samples in workload, personal responsibility and home-work balance, which were significantly higher sources of pressure for engineers. Thus, we found that engineers perceive a much higher degree of pressure in their job than four other occupational groups. The main sources of occupational stress in engineers' job were high workload, home-work imbalance and the need to take personal responsibility.

To test the relation of three main stressors in engineer's job, on the one hand, the correlations between workload, personal responsibility and home-work balance score were computed, and, on the other hand, the scores of the other sources of pressure in job were computed (see Table 2). Correlations ranged from 0.7 to 0.36 with all sources of pressure in job being statistically significant. Inspection of the correlations revealed some important tendencies. When focusing on high workload, a principal source of occupational stress in engineers' job, we found that the highest correlations were with relationships ($r=0.66$; $p<0.05$), as well as with home-work balance ($r=0.63$; $p<0.05$). The secondly highest pressure in engineers' job was personal responsibility. The highest correlation was between personal responsibility and managerial roles ($r=0.62$; $p<0.05$). The third source of high pressure for

engineers was home-work balance which, as already noted, correlated highly with workload and with managerial role ($r=0.52$; $p<0.05$). In addition, the highest correlation was between recognition and relationships ($r=0.7$; $p<0.05$). Thus, the data presented support the idea that engineers' high workload is the stressor which strongly relates to home-work balance and to relationships being associated with wider recognition. Engineers' personal responsibility as a stressor is associated with the need to take the managerial role.

Upon examining the inter-correlations between the quality of life domains, we found that all correlations were significant and ranged between 0.62 and 0.41 in five quality of life domains: physical health, psychological well-being, level of independence, social relationships, and environment. The correlations were almost significant but much lower (ranged from 0.41 to 0.2) for the domain of spirituality/ religion/ personal beliefs. Therefore, all the domains were highly (ranged from 0.82 to 0.66) and significantly correlated with the quality of life index.

Finally, correlations between the WHOQOL Index and the domains, and the eight engineers' occupational stressors were computed. Table 2 shows that the sources of occupational stress were negatively related to quality of life. However, the correlations between the WHOQOL Index and the domains, on the one hand, and the engineers' occupational stressors, on the other, were moderate or low.

An inspection of correlations between the WHOQOL Index and the sources of occupational stress showed that there were three significant correlations (hassles, personal responsibility, and organization climate) and they were far lower than expected.

Further investigating the relationship between the sources of occupational stress and the quality of life domains, as measured in WHOQOL-100, the most consistent correlations were found between the physical health domain and the sources of occupational stress. Physical health correlated moderately, being statistically significant, with all the sources of occupational stress, except one - recognition. The highest significant correlations with physical health were, in a decreasing order: hassles, personal responsibility, managerial role, workload and organization climate.

There were four engineers' occupational stressors – personal responsibility, hassles, managerial role and organization climate – that correlated significantly, but moderately, with the psychological well-being domain.

In case of two engineers' occupational stressors (hassles, organization climate), correlations were significant, albeit moderate or low, even with the four quality of life domains (physical health, psychological well-being, level of independence, environment), as well as the WHOQOL Index.

TABLE 1
COMPARISON OF MEAN SCORES OF SOURCES OF OCCUPATIONAL STRESS IN JOB (OSI-2)

Sources of occupational stress in job <i>Note - High score is for more pressure</i>	Mean and SD		Difference of Means (Sample 2 =0%)*	t-test for Equality of Means		
	Sample 1 - Engineers N=229	Sample 2 - Other Occupational Groups N=1005		t	Degrees of Freedom df	Sig. (2-tailed), p=
PW – Workload.	23.92±5.72	23.05±6.44	+3.7%	2.01	371.71	0.045*
PR – Personal Relationships.	34.21±7.34	33.44±8.19	+2.3%	1.41	368.96	0.159
PH –Home / work balance.	20.7±6.03	19.85±6.85	+4.2%	1.86	374.29	0.044*
PM – Managerial role	14.24±3.43	13.89±3.92	+2.5%	1.36	376.05	0.174
PP – Personal responsibility.	16.14±3.76	15.51±4.04	+4.0%	2.24	358.03	0.025*
PD – Hassles.	13.7±3.32	13.52±3.33	+1.3%	0.72	340.68	0.472
PC – Recognition.	16.05±3.81	15.57±4.33	+3.1%	1.68	374.32	0.095
PO – Organization climate	15.53±3.27	15.1±3.62	+2.8%	1.74	366.88	0.083

* Marked correlations are significant at $p \leq .05$

TABLE 2
CORRELATIONS BETWEEN SOURCES OF PRESSURE IN JOB (OSI-2) AND
QUALITY OF LIFE (DOMAINS AND INDEX WHOQOL-100) OF ENGINEERS

	PW Workload	PR Personal Relationships	PH Home-work balance	PM Managerial role	PP Personal responsibility	PD Hassles	PC Recognition	PO Organization climate
Physical health	-.20**	-.14*	-.15*	-.22***	-.28***	-.33***	-.09	-.18**
Psychological well-being	-.05	-.05	-.11	-.17*	-.26***	-.21**	-.02	-.15*
Level of independence	-.07	-.03	-.11	-.12	-.09	-.15*	-.02	-.14*
Social relationships	.03	.02	-.04	.02	.00	-.05	.04	-.05
Environment	-.10	-.04	-.07	-.05	-.11	-.18**	-.10	-.17**
Spirituality/ Religion/ Personal beliefs	.01	.06	.01	.00	-.04	.05	.07	.02
WHOQOL-100 Index	-.08	-.03	-.09	-.11	-.16*	-.17**	-.00	-.13*

*** Marked correlations are significant at $p \leq .001$

** Marked correlations are significant at $p \leq .01$

* Marked correlations are significant at $p \leq .05$

The relationship between the sources of occupational pressure and quality of life was negative as expected; almost all engineers' occupational stressors were negatively related to their quality of life, with stronger relations between the stressors and engineers' physical health and psychological well-being. Stressors such as hassles and organization climate had a negative, although a moderate or low effect on the WHOQOL Index, as well as on all quality of life domains, except on social relationships and spirituality/ religion/ personal beliefs.

IV. CONCLUSIONS

All eight studied occupational stressors - workload, relationships, home-work balance, managerial role, personal responsibility, hassles, recognition and organizational climate - had a stronger influence on the engineers' occupational group than on the standard group with representatives of four different occupations (managers, civil servants, lawyers, skilled workers from electronics industry).

The main sources of occupational stress in engineers' job were high workload, home-work imbalance and the need to take personal responsibility.

Engineers' high workload was the stressor which was strongly related to home-work balance and to engineers' relationships associated with wider recognition. On the other hand, engineers' personal responsibility as a stressor was associated with the need to take the managerial role.

The relation of the sources of occupational stress with engineers' quality of life was consistent being negative, yet moderate or low.

In the quality of life domains, the strongest relations were between the sources of occupational stress and engineers' physical health and psychological well-being.

In order to reduce engineers' occupational stress and improve their quality of life, a comprehensive occupational stress prevention system has to be created immediately; the system that is available to all should include both psycho-diagnostics (testing the occupation stress level, defining occupational stressors) and learning how to cope with stress.

B. Engineers' Occupational Stress Prevention System: E-psycho-diagnostics and E-learning

Occupational Stress Indicator (OSI-2) is available for the user in the Web environment. The user answers the OSI-2 test questions in the Web environment and the completed test is automatically sent to the recipient by e-mail once the user pushes the "send" button. The answers are then removed from the Web environment since according to the test manual, processing of the OSI-2 test takes place outside the Web environment. This ensures a copyright on the test key is not violated and the confidentiality of the user's test results is guaranteed. The data of the final test results are copied into and kept in a database outside the Web environment. The processed results of the OSI-2 test are sent individually to each user via the Internet at the e-mail address of the user's preference within 24 hours. The time delay occurs due to security reasons since the answers to the OSI-2 test have to be copied into a

database outside the Web environment, processed and copied again to a suitable format to be returned to the user. The length of the delay depends on the recipient (see Fig.1.).

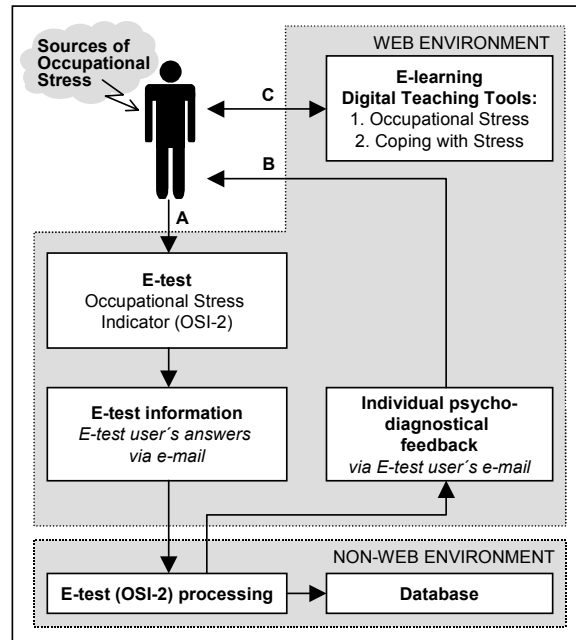


Fig. 1. Web-Based Occupational Stress Prevention System

The internet links for access to e-learning facilities and digital teaching tools "Occupational Stress" and "Coping with Stress" are attached to the test results upon return to the engineer (the user). Digital teaching tools "Occupational Stress" and "Coping with Stress" are free of charge for all users. The digital teaching tool "Occupational Stress" is a video-lecture about stress at work addressing the theoretical background of occupational stress, burn-out, the occupational stress risk scale, stressors at work, and some results of Estonian occupational stress research such as managers' stress and stressors at work and teachers' stress and stressors at work. The latter digital teaching tool is a video-lecture about coping strategies, problem solving, social support, time management etc. Both digital teaching tools include a video-lecture (35 minutes and 45 minutes respectively), slides presented at the lecture (15 items and 27 items respectively) and written materials for reading.

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From Collaborative Video Library to Annotated Learning Object Repository: Using Annotated Video Library in Personalized E-Learning

Md Maruf Hasan¹, Nophadol Jekjantuk¹, Yenruedee Chanwirawong¹, Ekawit Nantajeewarawat²

¹Shinawatra University, Thailand

²Sirindhorn International Institute of Technology, Thammasat University, Thailand

maruf@shinawatra.ac.th; nophadol_bkk@hotmail.com; yenruedeec@isd.th.ibm.com; ekawit@siit.tu.ac.th

Abstract – With the proliferation of digital and video cameras, personal collection of multimedia materials such as amateur video-clips are abundant now-a-days. Most of these multimedia materials may be useful to others if they are shared and can be located easily. Semantic Web technologies hold promise to organize and re-use such non-textual information effectively. However, annotation of multimedia contents is a tedious task. Notwithstanding, as we observe growing number of community collaborations on the present Web, such content annotation can be done through online collaboration. In this research, we investigate the development of a collaborative video annotation system using open technologies and tools where people can upload, annotate and share their personal multimedia collections efficiently. We also examine how the contents acquired and annotated with this collaborative system can be transformed into (1) Reusable E-Learning Contents for personalized learning; as well as, (2) Dynamic Digital Library with exploratory search and retrieval facilities using state-of-the-art Semantic Web technologies.

I. INTRODUCTION

Lecture materials such as those available under the MIT's Open Course Ware (OCW) initiative inherently consists of multimedia contents including video lectures and other non-textual objects [1]. Due to increased use of WWW in teaching and learning, e-learning contents have been increasingly available on the Internet. In this paper, we will use foreign language pedagogy and other intuitive (but simplified) examples to demonstrate the effectiveness of using collaborative annotation and Semantic Web technologies for sharing and re-using E-learning contents for personalized learning.

Videos play an important role in developing foreign language skills and apprehending foreign culture. Video clips for situational dialogue such as, shopping, dining, and opening a bank account etc. are highly reusable. For instance, a video-clip depicting the scenario of opening a bank account in English may easily be reused for learning French, and vice versa. Agencies involved in promotion of cultural exchange and tourism usually produce vast amount of multimedia

materials. However, most of these materials are often available with a few main-stream languages. Therefore, people without any knowledge in such languages fail to make better use of such materials. By adding metadata, transcription and subtitle to video contents, we can facilitate broader use of multimedia materials. For instance, a documentary video about Thai Folk Dance is commonly available in Thai, English or some other main-stream languages. However, with metadata annotations, transcription and subtitle in other languages; such materials can be equally useful for people who are not proficient in main-stream languages.

Over the last decades, with the ubiquity of the Internet and the growing popularity of the Web, we have witnessed growing number of successful small community collaborations on the WWW [2]. The success of such collaborations largely depends on the development of a sophisticated system (a collaboration platform) with easy-to-use interface and tool-support. In this paper, we investigate the development of a *Collaborative Video Annotation System* which can facilitate collaborative learning of foreign language and promotion of cultural exchange. We argue that with the increasing availability of Internet and bandwidth, digital divide is not always due to technological barrier but often due to our inability to integrate human sharing spirit and goodwill along with the technological advances.

II. SCENARIO OF FOREIGN LANGUAGE LEARNING

Main-stream foreign language learning materials have a huge market and therefore, publishers worldwide have been actively publishing study materials for the target market. Main-stream foreign language such as English has plenty of learning materials available in many native languages. However, it is truly unfortunate (and undesirable) that a Vietnamese often needs to learn Thai using learning materials written in English, and vice versa. The market-driven phenomenon left some languages far behind from the others. Our language and culture may or may not have a feasible market but they are our unique assets, and we ought to find ways to promote them using enabling technologies. By successfully utilizing the potential of the Internet and human spirit of collaboration, it is possible to promote our language and culture in an online collaborative fashion. The development of our video annotation system is inspired by

language education and cultural exchange by making use of the potentials of ubiquitous Web and online virtual collaboration.

Unlike some technological disciplines, foreign language teaching and learning follows a typical pattern and rather static. Off-the-shelf foreign language learning kits generally consist of lessons organized into different proficiency *levels*. For instance, the *Beginner's Level* consists of lessons with basic alphabet-set, phonetics and writing system along with greetings, basic vocabulary, simple grammars and conversations. The *Intermediate Level* materials go beyond the basics and include further lessons and practices with the help of situational dialogues and further syntactic, semantic and pragmatic notes and drills. *Advanced Level* learning materials are less restrictive and often go beyond typical textbook lessons – it is not uncommon to use real newspaper articles, movies, TV news or documentaries to teach different linguistics and cultural facets to the advanced learners. In many cases, we noticed that a vast majority of these off-the-shelf software products are mere digitization of their predecessors - the video-based learning kits. However, there are some exceptions. For instance, ELLIS [3] – an English learning software tries to integrate ESL pedagogical research with computer and networking technologies. Such materials are often expensive and beyond the purchasing power of individuals.

In terms of contents, we noticed many similarities across foreign language learning materials. Unless commercially motivated, contents such as alphabet chart, pronunciation audio files, grammar flashcards, situational dialogue videos could have been reused effectively for teaching that foreign language to any native language community through some customization and annotation.

Screenplay [4], a Japanese publisher uses foreign films to help Japanese learners improve their foreign language ability. Using their Web site and multimedia products, a user can also conduct associative search to see a word in the real context. This is not only effective as endorsed by scholarly research findings [5], but also a fun activity which promotes the understanding of culture, etiquette and social practice beyond mere language learning through memorization of grammar rules, substitution drills, and the like.

III. SCENARIO OF CULTURAL EXCHANGE

Governments and agencies across the world do invest huge amount of money and efforts in producing documentaries and other multimedia materials for the promotion of culture and tourism. However, their focus remains limited to some targeted audiences (and therefore, limited to a few mainstream languages). For instance, most documentaries and videos developed in Japan are often available in Japanese, English, French, and Chinese, etc. Unless properly annotated with metadata, transcripts, subtitle or soundtrack, it is unlikely to find those materials useful for an audience who do not understand any of these languages.

With our decades of experience with other online collaborative projects, such as Project Gutenberg [6] and

Aozora Bunko [7] - where copyright-free books are digitized and even translated by volunteers worldwide, we expect that such promotional video materials can equally be annotated collaboratively and free-of-charge as long as an easy-to-use collaborative system is available and online volunteers are supported with easy-to-use interface and tools.

IV. COPYRIGHT AND OTHER ISSUES

It is a fact that commercially developed materials may not be available free, but it is inevitable that some promotional materials from *not-for-profit* agencies and governments may gradually become available publicly. We also rely on amateur personal videos taken by digital and video cameras as a good starting point. The Open Video Project [8] is a general digital library of publicly available videos from unrestricted domains – ranging from classroom lectures to public service or documentary videos – may also be imported and annotated in our system. However, at the moment, we target to gather and annotate video and multimedia materials in a *restricted domain* through small-community collaboration. Our primary goal is to promote cultural exchange and facilitate foreign language education while making full use of the ubiquitous connectivity of the Internet and the growing human spirit of virtual collaboration on the WWW. In doing so, we focus on developing an easy-to-use collaborative video annotation system which we have explained in this paper in detail. We also refer to our other publications on creation of sharable and reusable E-Learning materials using a component-oriented approach [9] – where we demonstrated that such annotated contents with proper metadata, and relevant structural, semantic and pedagogical information, it is possible to generate customized and personalized course materials for *any* discipline (not restricted to foreign language learning).

In any voluntary online collaboration, *motivation* plays a crucial role. The success of our initiative therefore, remains on the enthusiasm of volunteers who take pride and care about their own language and culture. The evidence of the steady growth of collaborative projects on today's Internet and WWW (e.g., the Open Video Project as mentioned earlier) is encouraging. Moreover, a collaborative project such as this one requires a *critical-mass* of volunteers and contents to become successful. It is obvious that unless we have a handful number of volunteers or a sizeable amount of contents, our initiative may not receive sufficient attention quickly.

With an initial support from *Asia-Pacific Telecommunity* (APT) and *Thailand Research Fund* (TRF), we have initiated this project and developed a fully working prototype which is currently operational at <http://apt.shinawatra.ac.th/video/>. Some of our international collaborators are consistently supporting us by developing or accumulating useful contents for promotion of foreign language and culture on the cyberspace. We envisage that we will continuously receive supports from governments and agencies to develop this project further.

In the rest of the paper, we will explain the implementation details and major features of this video annotation system followed by their effective application in E-Learning.

V. THE COLLABORATIVE VIDEO ANNOTATION SYSTEM

The video annotation system we developed is fully Web-based. Users interact with the system using their Java-enabled Web-browsers without having to resort to any video plug-in. We choose *MediaFrame* [10] – an open-source software for streaming video manipulation and playback. We use *MediaFrame*'s JavaScript API, PHP scripts and MySQL database to develop our video annotation system. The technical complexities of the system remain hidden to the users since users interact with the system using an easy-to-use Web interface.

A. *MediaFrame: Streaming Media Player*

MediaFrame is an open-source streaming media platform in Java™ which provides a fast, easy to implement, and extremely small applet that enables web users to view audio/video contents without having to rely on external player or plug-ins. *MediaFrame* does not require special servers, software or programming knowledge. Integration of *MediaFrame* with other applications becomes easy due to its well-defined JavaScript API and its support to Mpeg-1 and Mpeg-4 video formats.

MediaFrame can deliver audio and video contents over the Internet in either streaming or progressive download mode. It is also capable of stretching media by up to 60% of its original size without a significant loss of quality. This enables us to simulate higher bit rates without the associated costs and to operate effectively in both broadband and narrowband environments. We want our system to be reachable by people in the remote area where the infrastructure is not as good, or may have to resort to satellite links for a connection. *MediaFrame* is capable of detecting user's connection speed in real-time and delivers media accordingly.

A full-featured *Digital Rights Management* (DRM) system is also integrated with the core of *MediaFrame* allowing media files to be locked to a specific domain and expired over time. This feature is crucial in disseminating copyrighted/restricted contents.

Moreover, *MediaFrame* is fully JavaScript controllable; making it simple to build our own control set and to integrate it with our video annotation system seamlessly. Using the JavaScript API, we could also conveniently add transcripts and subtitles to video materials. The multiple-playback-state feature also allows us to tightly integrate *MediaFrame* for effective video annotation and playback.

B. *Metadata Annotation*

For non-textual materials, such as videos, descriptive metadata plays an important role in exploratory search and browsing [11]. MPEG-7, LOM and SCROM [12] are sophisticated metadata sets for multimedia content annotation. However, we adopt a simpler subset of descriptive metadata for the system in order to avoid fears in the ordinary users. At the moment, the system allows users to annotate a video-clip with *Title*, *Genre*, *Original-Language*, *Keywords*, *Descriptions* and some other essential metadata. Whenever applicable, structural metadata such as *Video Format*,

Duration, *Color*, etc. are extracted automatically from the video file.

C. *Supplementary Annotations*

The video annotation system allows a user to step through a video-clip and to add transcripts along with its original soundtracks and transcripts. User can also select transcript in an available language and translate it into a target language. During playback, users can choose from available transcription-languages to be displayed as subtitle with the video (cf. Fig 1-4).

It should be noted that for effective learning of foreign language using video, transcriptions need to be further annotated with extra information such as, pronunciation and grammatical annotations or relevant cultural notes. Such features are currently being implemented.

D. *Some Representative Video-clips and Their Annotations*

In this subsection, we explain a series of video-clips from our system, which summarize the effectiveness of our system in the context of language learning and cultural exchange.

Fig. 1 shows a situational dialog video-clip from ELLIS played with English (Fig. 1a) and Thai subtitle (Fig. 1b). Fig. 2 shows amateur video-clips of Kashima Jingu Shrine in Japan (Fig. 2a), and about Japanese Paper Art (Origami, Fig. 2b) – although the original soundtrack is in Japanese, English subtitles are made available through online annotation, and displayed accordingly. Fig. 3 shows a video tutorial from JEITA about *Natural Language Processing* (NLP) technology (originally with Japanese soundtrack) but is being played with English subtitles since such information has already become available through online annotation. In doing so, we made it possible for non-Japanese audience to benefit from this tutorial

For all these video-clips, descriptive metadata are also available in the system (annotated collaboratively and indexed automatically) to facilitate exploratory search and navigation [11]. Users can use keyword search (analytical strategy) or browse (partition strategy) the video collection effectively with the help of relevant metadata.



Fig. 1a. Situational dialogue in a bank (played with English subtitle).



Fig. 1b. Situational dialogue in a bank (played with annotated subtitle in Thai).



Fig. 3. A video tutorial developed by JEITA on *Natural Language Processing* – originally in Japanese, but we added English subtitles and descriptive metadata online.



Fig. 2a. Amateur video-clip: Kashima Jingu Shrine in Japan (original soundtrack in Japanese but played with annotated English subtitle).



Fig. 2b. Amateur video-clip: Japanese Origami or Paper Art (original soundtrack in Japanese but played with annotated English subtitle).

Finally, Fig. 4 shows an example video annotation interface. Video is displayed with playback control, time-stamp and other information. In the process of filling in the *Time* and *Subtitle* boxes below, annotating user can choose reference subtitle from available source languages, and control the video playback with control buttons as necessary. All other annotation interfaces are similar browser-based, and therefore, easy-to-use.

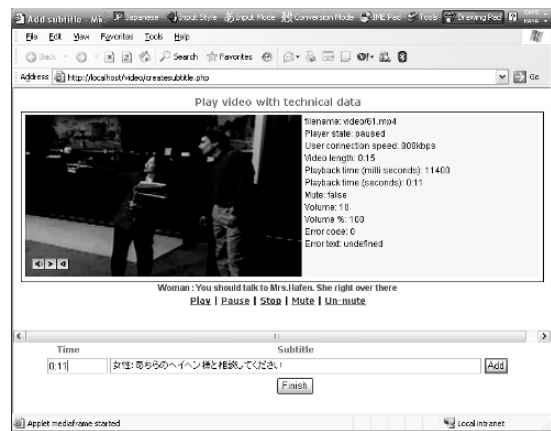


Fig. 4. Subtitle annotation interface: User can choose a source language and add subtitle in a target language. Timestamp and Playback Control are displayed as video-clip is being played.

VI. APPLICATIONS OF ANNOTATED VIDEO LIBRARY

The video annotation system serves as a *platform* for *small community collaboration* online as well as an *input channel* of contents. Multimedia contents gathered, annotated and manipulated in this way should be used (disseminated) in useful applications. The following two subsections explain

two unique applications in personalized E-Learning and dynamic Digital Library.

A. Intelligent Dissemination of E-Learning Contents

The success of gathering and disseminating sharable, reusable and customizable e-learning contents depends on developing an easy-to-use collaborative system – a system that not only hides the complexities behind a simple form-like web interface (for submission, annotation, retrieval, and the like), but also organizes and manipulates contents in a structured and efficient manner so that intelligent inferences can also be made. For example, content-level dependencies should be propagated and preserved at lesson or course level and so on. Semantic Web technologies including metadata and domain-ontology are used in the background so that both humans and software agents can equally effectively access and manipulate the annotated contents from the video annotation server.

We proposed a 3-Tier Architecture for component-oriented E-Learning Content Management [9] as shown in Fig. 5. We use ontology to organize contents and ontology-based reasoning to make inferences about contents such as content dependency or other pedagogical attributes. Given that we have gathered and annotated contents with their pedagogical attributes, our current E-Learning prototype can respond to user’s content needs intelligently. For instance, finding contents for “10-hour lessons for introductory Japanese focusing on greetings and everyday conversation”, or a “42 hours of course materials for a System-oriented Database course” - can be created on-the-fly as long as annotated contents are available.

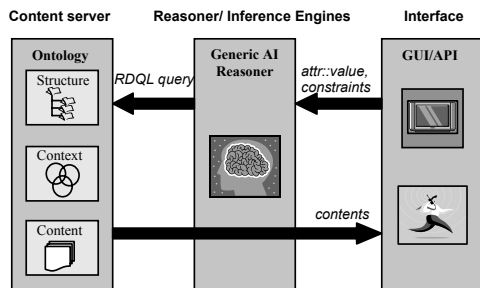


Fig. 5. 3-Tier E-Learning Content Management Architecture.

A currently working prototype is available at <http://apt.shinawatra.ac.th/ecms/>. Internally, we organize the contents in an OWL-ontology based on the annotated metadata. Our current prototype uses a *Semantic Web Reasoner* (OWL-based Pellet, [13]) to identify appropriate contents from the ontology that satisfy user’s criteria. Users interact with the system using Web-based interface. Fig. 6a and Fig. 6b explain how user may specify different constraints and find appropriate contents that satisfy their criteria and content dependency from a Database related course contents.

For example, a teacher or a learner trying to retrieve a 20-hour Foundation Course in Database only needs to specify the criteria through the Web-based interface (Fig. 6a). User

criteria and content dependencies are then verified using a *Generic AI Reasoner* to locate the appropriate contents. The user is then presented with the appropriate contents in an organized fashion (Fig. 6b).

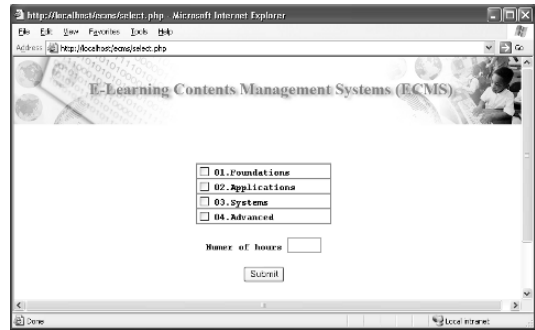


Fig. 6a. Search interface of E-Learning contents (example shows contents search for a Database course contents).

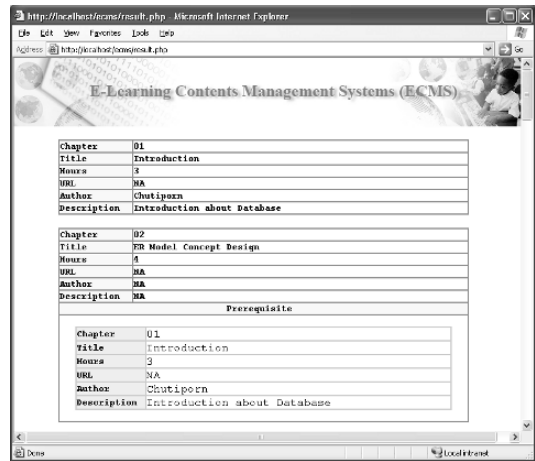


Fig. 6b. E-Learning contents retrieved and presented in an organized fashion. Output reflects the criteria/constraints specified by user as well as content-level dependencies.

B. Dynamic Digital Library

Using Semantic Web technologies and exploratory search and browsing interfaces as explained in [11] and tested on Open-Video collection [8], we plan to disseminate our multimedia-contents arriving from the video annotation system (i.e., live *input channel*) in the form of *Dynamic Digital Library*. For example, a user interested in Temples and Pagodas in a particular region will define a *Library Template* by specifying the nature of contents (such as, video-clips of Temples and Pagodas in Thailand can be easily specified since our contents are annotated with descriptive metadata and organized in an ontology). Contents and their organizations in such dynamic libraries are automatically updated as new

materials are deposited or contents are updated, annotated or reorganized on the video annotation server.

VII. CONCLUSIONS

In this paper, we outlined an operational prototype of a collaborative video annotation system developed for foreign language education and cultural exchange in mind. We often ignore the fact that majority of Internet users are not proficient in foreign language and therefore, materials available on the WWW in a foreign language has little or no use to those people. Multimedia materials, such as videos are relatively easy to understand or appreciate without *complete* translation (since contextual, visual and other cues are present). Nevertheless, it is extremely difficult to locate non-textual materials on the Web using today's keyword-dependent *hit-or-miss* search engines which heavily rely on textual indexing. Metadata annotation is therefore essential and can be done effectively in small-group collaboration. We do admit that we are yet to conduct any experimental evaluation of the proposed system to justify the effectiveness of this approach. However, our future work will eventually attempt such evaluations and vigorous live trials.

We have also outlined an ontology-based *E-Learning Content Management* prototype for *personalized* E-Learning. We have plans to organize our video collections using Semantic Web technologies to support personalized foreign language education. We explained how our annotated video library with its multimedia contents can serve as (1) an *E-Learning Content Server* - storing both contents and structures (contents with annotated pedagogical attributes in an ontology) to facilitate personalized E-learning; and, (2) a *Digital Library Content Server* - storing amateur videos as well as professional multimedia (contents with annotated language and cultural attributes in an ontology) to support cultural exchange and foreign language learning tasks.

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FLOE-T: TOOL TO MEASURE THE QUALITY IN LEARNING OBJECTS

Miguel Vargas
Manuel Ortega

Computer-Human Interaction and Collaboration, Research Group
Universidad de Castilla-La Mancha, Universidad Tecnológica de Panamá, SENACYT-Panamá
Paseo de la Universidad 4, Ciudad Real (Spain) 13003, Telephone, 0034-926 295300 Ext: 3735
miguel.vargas@utp.ac.pa, manuel.ortega@uclm.es

This paper bridges the gap between the theory of learning objects and real applications. We take learning objects at random from the repositories of Research Channel that is a nonprofits media and technology organization that connects a global audience with the research and academic institutions whose developments, insights and discoveries affect our lives and futures.

We apply a framework for the evaluation of objects (Learning Objects). The main objective is to present cases of study of the implementation of the model Framework for Learning Object Evaluation (FLOE). In these cases of study the quality of the Learning Objects is evaluated through four aspects: positive quality, negative quality, delivery and formative quality.

I. INTRODUCTION

With the proliferation of on-line learning courses and materials, the Web is now replete with vast amounts of duplicated data and information. Much of the design and development of Web-based materials has previously focussed, and still continues to focus, on the delivery of on-line content [28]. The content-based approaches which are commonplace in the online world are characterised by:

- courses of instruction where learners are provided with readings and course material which they follow in a very guided and directed way.
- learning environments that closely resemble the lecture-workshop format of teaching and learning in a face-to-face mode.
- learning materials designed specifically for the context in which they are presented.
- limited reuse and sharing of materials.

Much has been made about how the world has changed because of the advancement of digital technology into our daily lives. For example, reminds us that people are using the Internet and digital technologies to level the playing field worldwide especially in the business environment—so that knowledge and services are readily accessible and available through cost-efficient means and by anyone, anywhere, and at any time. How does such a notion transfer into the world of higher education? We only have to look at the rise of private online universities to get a prime example of how digital technology is transforming the landscape of today's university. There many ways from the students we educated when the digital revolution first swept college campuses.

The Learning Objects provide a great answer to the individual and collective formation because they include a set of digital materials mainly, that as unit or group allows or facilitates to reach an educational objective, with varied technologies within the context of ICT.

To a great extent, in the Portals an extensive variety of Learning Objects is grouped Educational Software Components of Tomorrow [25], Multimedia Educational Resource for Learning and On-Line Teaching (MERLOT), Research Channel and Apple Learning Interchange (ALI).

Experts and companies [3], [4], [5] suggest benefits when using Portals in aspects like:

- Increase in productivity.
- Accelerated and public resolution of processes with a reduced effort.

- Improvement in the relationship among clients, partners, and suppliers due to the collaboration inside and beyond the limits of the organization.
- It improves the information search

Therefore, in the first section of this article are analyzed the characteristics of the virtual education, the importance of the Portals, and the Learning Objects. Also some comments about the Learning Objects by Wiley [38] are exposed, and the opinions of specialists in subjects of Portals [11], [12].

The opinions of Merlot are analyzed under materials learning. Next, the model Framework for Learning Object Evaluation (FLOE) is described. Later, some Learning Objects and their evaluation are presented. Finally, we will present the conclusions and future works.

II. LEARNING OBJECTS IN PORTALS

The portals are instruments for searching, navigation, help, and personalization. They allow the users to personalize their information sources choosing and taking only the information that they find personally useful; including if related to private information [11], [12], [9].

When a user can specify his behaviour, aspect and content, a Portal is individualized. A Portal is a channel between the supplier and its hearings.

The Portals [5], [17], [25],[22] offer a wide variety of Learning Objects arranged to facilitate knowledge. Many of these objects that interact within the technological infrastructure of Portals are described through Wiley [38].

A. Characteristics Learning Objects

A Learning Object must have the following characteristics[38]:

- Number of combined elements
The number of individual elements (such as video clips, images, etc), combined to make the Learning Object are described.
- Type of objects included.
Describes the type of Learning Object that can be combined to form a new Learning Object.
- Common Function.
Describes the way in which the type of Learning Object generally used.
- Additional dependence from the object.
Describes if the Learning Object needs the information (as location in the web) about other Learning Objects, with the exception of itself.

- Type of logic contained in the object.

Describes the common function, of the algorithm that constitutes it and the procedures of the Learning Object.

- Potential of the context for inter-re-use.

Describes the number of the diverse learning contexts in which the Learning Object could be used, this is, the potential of the object for re-use in diverse areas or domains.

- Potential of the context for the intra-re-use.

Describes the number of times in which in the Learning Object could be re-used in the same area or appropriate domain.

Without doubt, these characteristics allow to have a more specific idea on the scenarios in which the Learning Object are based and thus, to deepen in the quality that these must have in the portals. At the present time, one of the aspects that occupy and concern the experts in E-Learning is the definition, elaboration and use of the denominated "shared or re-usable learning objects" (Sharable content objects or Reusable Learning Object), which allow to form bases of didactic contents (Learning objects repositories) that can be used in different educative contents and for different addressees, with the consequent economic and effort saving, and with the added advantage of being able to be reused by many users of E-learning [35], [21].

B. Types of Learning Materials

Since 1998, Merlot groups immense repositories of Learning Objects. Through the following classification:

Simulation

Real or imaginary experience.
Users' actions affect their outcomes.

Animation

Visual representation of concepts, models, processes.
Users control pace and movement through the material.

Tutorial

Electronic workbook designed to meet stated learning objectives.
Structured to impart specific concepts or skills.
Organized sequentially.

Lecture/Presentation

material used in support of in-class lectures/presentations.
Notes, AV materials, and presentation graphics.

Case Study

Illustrates concept or problem by using example that is explored in depth.

Collection

Any collection of images, sequences, learning materials as web sites or subject specific applets.

Reference Material

No specific instructional objectives.
Similar to that found in the reference area of a library.

We must remember that MERLOT, ALI, Research Channel are some of many of the repositories of learning materials or learning objects.

Since 1988, the industry, educational institutions, and particular groups, facilitate the E-learning process by promoting standards and guidelines in a global initiative to develop effective educational models through distance education using Internet as is the case of [2], [4], [6], [19].

As a previous step to its reusability, we propose a framework to evaluate the quality of the Learning Objects based on four scenarios: positive quality, negative quality, delivery and formative quality. In the following section we explain in what the framework of this proposal consists to guarantee quality in the Learning Objects.

III. A FRAMEWORK FOR LEARNING OBJECT EVALUATION (FLOE)

The interest for evaluating the Learning Objects is suggested by authors like [29], [24], [23], [10]. Based on their questionings we study the optimum levels in aspects such as usability, accessibility, and learning in the Learning Objects. Similarly, a model to evaluate a Learning Object from the environment of the portals is proposed. In it, the perspective of quality of the Information and Communication Technologies [1] is analyzed, managing to determine its worth as an object that provides learning and, subsequently, knowledge to the user of the Learning Object. For the development of this model, we utilize the Cobit's

evaluation objectives or criteria[13], for the Information and Communication Technologies [1]; and the model proposed by Kirpatrick [16] for the evaluation of traditional formative actions, that, currently, various authors recommend their adaptation and use in E-learning[8],[32],[34]. Subsequently, are developed the four scenario of study of this proposal (see fig. 1. Evaluation Scenarios).

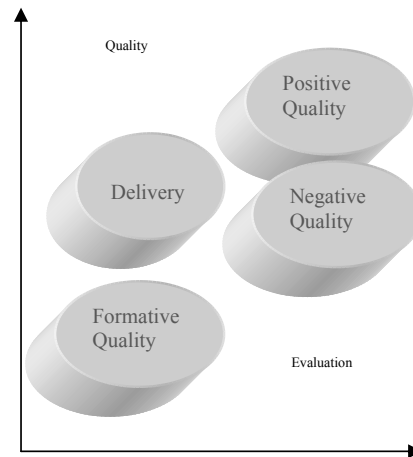


Fig. 1. Evaluation Scenarios FLOE.

The criteria utilized permit to formulate general scenarios. From them, we obtain specific scenarios to build an experimental model for the evaluation of Learning Objects. The general and specific scenarios for the evaluation of Learning Objects are the following:

Positive quality: It examines the quality of presentation and visibility of the information. It integrates three specific scenarios:

- Velocity: the ideal state of the information in real time is evaluated.
- Simplicity: the simple integration in the interface is evaluated.
- Utility: a conceptual model of representation, interactive, comprehensive, to improve the sensation at sight is evaluated.

Negative quality: Belonging to the quality of the applications of Information Technology that are transparent to the users. It contemplates three specific scenarios:

- Completeness: information without error and without duplications.
- Accuracy: correct, exact; captures exactly the state of the resources.
- Authorization/Validation: continues the intentions of managements to protect them against unauthorised modification.

Delivery: Comprehends how, when, and why the information technology is made available to the user. It comprises three specific scenarios:

- Availability: accessible and useable when is required.
- Confidential: it communicates only to the ones that have the right or need to know.
- Autonomy: independent and easily replaceable.

Formative quality: Examines the efficiency and effectiveness of the framework of learning of the specific scenarios that are: reaction, learning, transfer, and impact.

- Reaction: Treats the impact that the user perceives from the elements of learning, like the educator, the contents, the materials, and the learning.
- Learning: is evaluated to verify the level of knowledge and abilities acquired by the user.
- Transfer: consists of detecting if the activities developed permit to achieve a formation inside the work environment.

- Impact: It is intended to identify if the lack of training has a negative effect in the organization or on the user.

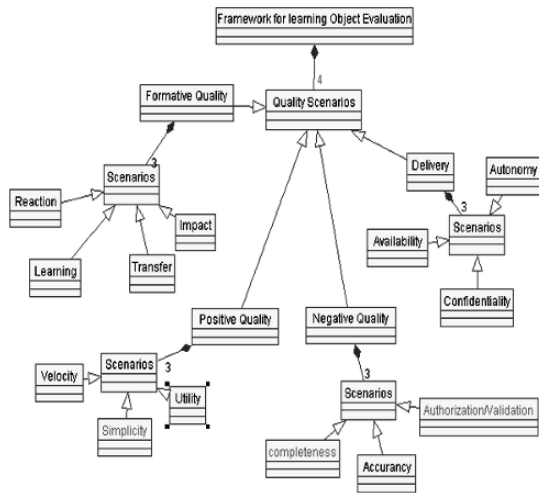


Fig.2 Extending the model, FLOE

The model and framework FLOE (See.Fig.2 extending the model FLOE), proposed was developed to evaluate the Learning Objects from the perspective of the ITC-USER, ITC-LEARNING and USER-LEARNING, in the environment of the portals. It also evaluates the knowledge and learning that is produced from the man-machine-learning-knowledge combined interaction.

A. Evaluation Scheme for FLOE

The purpose of this scheme is to develop the experimentation of FLOE. (See Table.1 Scheme for the evaluation of a Learning Object).

Scheme for the evaluation													
L O Na- me	Positive Quality			Negative Quality			Delivery			Formative Quality			
	Velocity	Simplicity	Utility	Completeness	Accuracy	Authorization/V validation	Availability	Confidential	Autonomy	Reaction	Learning	Transfer	Impact

Table.1 Scheme for the evaluation of a Learning Object. Evaluation (P,S,B)

From left to right, the scheme presents in its first column the Learning Objects of the Portal of (Online Interactive Module for Teaching Computer Science) which will be evaluated. Next, grouped in three columns until completing thirteen (13), we indicate the general and specific scenarios that will be evaluated in the proposed model for the Evaluation of a Learning Object.

To achieve an effective evaluation, the following classification will be used:

We will evaluate with a (P) Primary, if the Learning Object, when examined, impacts favorably the requirements that concern to the Information Technology and to the formative quality. A (P), Primary, will be marked in the corresponding booth for the specific objective of the particular Learning Object.

We will evaluate with an (S) Secondary, if the Learning Object, when examined, satisfies in lower or unsatisfactory degree the requirements that concern to the Information Technology and the formative quality. A (S) Secondary, will be marked in the corresponding booth for the specific objective.

We will evaluate with a (B) Blank Space, if the Learning Object, when examined, only satisfies appropriately other criteria that do not correspond to the process that concerns to the Information Technology and the formative quality. A (B), Blank Space, will be marked in the corresponding booth for the specific objective.

Having explained the evaluation scheme we start the experiment taking as object of study the portal [7].

B. Cases of Study experimentation with FLOE, The Research Channel

For the process of evaluation is used as reference the ResearchChannel[31] that was founded in 1996 by leading research and academic institutions so they could share the work of their researchers with the public. These ideas are shared in their original form — unmediated and without interruption.

Now we start to fill the scheme by listing two Learning Objects that are found in the Portal of the Research Channel, See (Table 2, Random Learning objects from Research Channel; Table 3.Evaluation of Learning Objects from Portals).

Table 2. Learning objects from Research Channel

Learning Objects	A. An Unknown History of Science in America at The Franklin Institute	The Franklin Institute offers an electronic presentation of its Case Files, a collection of primary source documents that exists as an unknown repository of the history of science and technology. The University of Pennsylvania's Department of History and Sociology of Science hosted a Symposium to discuss the historical, scientific, and educational merit of the Case Files, which date from the 1820s, as a modern day resource for undergraduate, graduate, and professional scholars, as well as K-12 students.
	B. Addressing Childhood Obesity	Obesity is no longer just an epidemic in the adult population. The rising rate of childhood obesity has also become a major concern for the medical community. Stanford's Assistant Professor of Pediatrics and Medicine, Dr. Thomas Robinson, examines the health and societal problems children face, as well as possible solutions currently being studied to keep kids fit and happy.

Evaluating:

Table 3. Evaluation of Learning Objects from Portals

L O	Positive Quality			Negative Quality			Delivery			Formative Quality			
	Velocity	Simplicity	Utility	Completeness	Accuracy	Authorization/V validation	Availability	Confidential	Autonomy	Reaction	Learning	Transfer	Impact
A	B	S	S	B	B	B	B	S	S	B	B	B	B
B	B	S	S	B	B	B	B	S	S	B	B	B	B

The exam will be carried out to the following objects (Learning Objects):

- A. An Unknown History of Science in America at The Franklin Institute
- B. Addressing Childhood Obesity

The results obtained are: See (Table 2. Evaluation of Learning Objects from Portals):

Positive Quality: The (Learning Objects) evaluated through the model have an evaluation of (B) Blank Space because in aspects like speed, is null speed in the connection[3]. In Simplicity and Utility its evaluation is (S) Secondary; because, neither the specifications indicated by [19], [14] are fulfilled; nor the aspects of usability indicated by [30], [33], [37], [36] are considered.

Negative Quality: In Completeness, Accuracy, Validity/Authorization, their evaluation is (B) Blank Space, because it does not fulfill the objects transmit consistency in the management of information without errors[3],

the resources are utilized in a favorable form by the users, and the free access to the contents which is the intention of the Portal's Management; are followed.

Delivery: In the aspect of availability, its evaluation is (B) Blank Space, because it does not fulfill the conditions of Information and Communication Technology are fully satisfied by corresponding to th needs of counting with information always available[3]. Confidentiality and Autonomy are aspects evaluated with (S) Secondary, because the objects are of free use for the users of the Portal which implies that they can be altered [15].

Continuing with the process of evaluation of the (Learning Objects) of the Portal Research Channel, we analyze them from the perspective of formative quality.

Our evaluation is (B), blank space [27], [26], [20] when formative quality of learning objects don't permits to describe the interaction of the user and the object.

C. Cases of Study experimentation with FLOE, Teaching-Learning Innovation Center of the University of Virginia Tech.

For the process of evaluation is used as reference the Portal [7]: Teaching-Learning Innovation Center of the University of Virginia Tech. (See fig. 2.)



Fig.2.Teaching-Learning Innovation Center of the University of Virginia Tech.

Now we start to fill the scheme by listing six Learning Objects that are found in the Portal of the Machine Architecture module of the Teaching-Learning Innovation Center of the University of Virginia Tech [7]. See (Table 4, Evaluation of Learning Objects from Portals).

Evaluation of Learning Objects from Portals													
Learning Objects	Quality (Positive)			Quality (Negative)			Delivery			Formative Quality			
	Velocity	Simplicity	Utility	Completeness	Accuracy	Authorization/Valid	Availability	Confidential	Autonomy	Retention	Learning	Transfer	Impact
Introduction to Machine Architecture	P	S	P	P	P	P	P	P	B	B	B	B	B
Data Store	P	S	P	P	P	P	P	P	B	B	B	B	B
Gate	P	S	P	P	P	P	P	P	B	B	B	B	B
Human Vs Computer	P	S	P	P	P	P	P	P	B	B	B	B	B
Circuits	P	S	P	P	P	P	P	P	B	B	B	B	B
The Central Processing Unit	P	S	P	P	P	P	P	S	B	B	B	B	B

Table 4. Evaluation of Learning Objects from Portals.

The exam will be carried out to the following objects (Learning Objects): Introduction to Machine Architecture, Data Store, Gate, Human Vs Computer, Circuits, and The Central Processing Unit. The results obtained are: See (Table 4. Evaluation of Learning Objects from Portals):

Positive Quality: The (Learning Objects) evaluated through the model have an evaluation of (P) Primary because in aspects like speed, the interest in the theme is not lost by the scarce or null speed in the connection. In Simplicity and Utility its evaluation is (S) Secondary; because, neither the specifications indicated by [14],[18],[19],[22] are fulfilled; nor the aspects of usability indicated by [30],[33],[37],[36], are considered.

Negative Quality: In Completeness, Accuracy, Validity/Authorization, their evaluation is (P) Primary, because the objects transmit consistency in the management of information without errors, the resources are utilized in a favorable form by the users, and the free access to the contents which is the intention of the Portal's Management [7]; are followed.

Delivery: In the aspect of availability, its evaluation is (P) Primary, because the conditions of Information and Communication Technology are fully satisfied by corresponding to the needs of counting with information always available. Confidentiality and autonomy are aspects evaluated with (S) Secondary, because the objects are of free use for the users of the Portal which implies that they can be altered .

Continuing with the process of evaluation of the (Learning Objects) of the Portal, we analyze them from the perspective of formative quality. The evaluation will be comprised of the development of a questionnaire that will be applied before and after starting the interaction of the participants with the objects. This questionnaire is composed of eleven questions Kirkpatrick. To measure the results a simple relation among the number of questions answered and not answered will be used. The relation will be calculated using this equation. Use "(1), EP: Pedagogical efficacy":

$$EP = \frac{C 2}{P 1} - \frac{C 1}{P 2} \times 100 \quad (1)$$

Where:
 EP = pedagogical efficacy of the course, seminar, etc. (expressed in %).
 C2 = number of questions answered correctly in the Post Test.
 C1 = number of questions answered correctly in the Pre Test.
 P2 = total of questions formulated in the Post Test (11 questions).
 P1 = total of questions formulated in the Pre Test (11 questions).

To obtain data the questionnaire was applied to the twenty participants of the experiment obtaining the results presented in the fig. 4. Percentage of Answers by Questions, (Formative Quality).

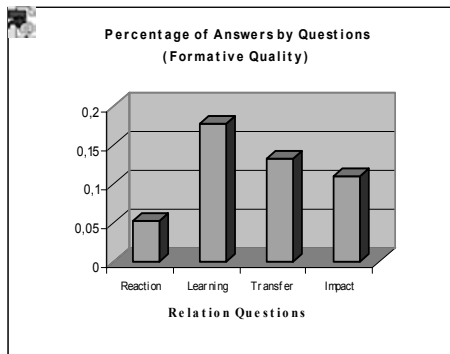


Fig. 4. Percentage of Answers by Questions, (Formative Quality).

P (Primary % > 80 %)

S (Secondary % between 50 and 80%)

B (Blank Space % < 50%)

In Reaction (percentage 0.05), the evaluation is (B) blank space. The participants showed little interest for these objects, considering them as not interesting, because the contents reflect a good thematic in their development but not quality in the interaction of the interface with the users.

Regarding the Learning (0.18percentage), its evaluation is (B) blank space. The participants showed scarce interest in learning, demonstrating a limited level of knowledge regarding factors like the non-existence of objects that reinforced the learning and provided feedback of experiences from the Learning Object.

As for Transfer (percentage 0.13), its evaluation is (B) blank space. It was shown that the environment impedes to share and interact among the participants.

The Impact (percentage 0.11) that experienced the participants showed lack of training, and a scarce or null capacity to adapt to the new educational paradigms that form part of an unstoppable progressive tendency in modalities of self-instruction and E-Learning. Consequently, its evaluation is (B) blank space.

IV CONCLUSION AND WORK FUTURE

Our intention is to propose this framework (FLOE), like an effective tool of work for the obtaining of objects of quality learning. Through this framework, they are solved some of the quality aspects e-learning like:

- Abilities for the use of the new information and communication technologies.
- Capacity to adapt to the new learning surroundings.
- Contents that have to be learned.
- Methodologies of education-learning.
- Multimedia resources.

We have demonstrated that all the repositories of Learning Objects are not of quality. And that is necessary a greater study on the quality of the repositories of learning objects [5], [22] and Research Channel[31]. Because, the reusability of learning objects, is even a complex process, since we have seen in this experiment. In future works we will develop software that studies and evaluates learning objects based on FLOE using a new tool Floe-T.

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Computer Aided Architectural Design Training

M. Dobelis

Riga Technical University, Riga, LV-1658, Latvia
Tel. +371-708-9225; e-mail: dobelis@acad.latnet.lv

Abstract- The present time can be characterized as an era of digital revolution which has resulted in a creativity burst in different design applications. Rapid advancements in Information Technology (IT) are still under way and are widely used to communicate architectural design projects. The paper deals with an exploration of some elements of IT – how they can be integrated into both architectural design process and university curricula. In academic courses contemporary CAAD knowledge basically is about the development of computer aided creative and problem solving skills in the context with fast changing CAAD media. It becomes more difficult to teach the common principles behind individual software which is general and will most likely survive ever-changing software versions. Limited university class contact hours for the subjects do not allow developing of detailed courses for the training of particular software. A case study is presented about the evaluation of the capability of the architectural students for their problem solving skills. Statistical analysis of the data revealed strong linear correlation between the time to complete particular exercises and preliminary CAD competence level among the students, thus clearly demonstrating the significance of CAD training in effective usage of software.

INTRODUCTION

Computer Aided Architectural Design (CAAD) undoubtedly has become a recognized design media rather than design tool and is widely accepted by architectural practitioners. The general goal that architects go after is visual expression, design and illustration of their projects or ideas using both professional experience and personal computerized creative skills. CAAD is a particularly dynamic field that is developing through the actions of architects, software developers, researchers, technology users, and society alike. Therefore, rapid advancements in information technologies are almost immediately used to communicate architectural design projects.

The rapidly developing technology of the 21st century has transformed the general use of computers into a specific, convenient, and necessary tool for professionals [1]. With great success these achievements are also explored by architects and designers. However, architects often face the problems associated with the peculiarities of user-computer interface that was inherited from the times when computers were only used by computer professionals for the purposes other than arts, and these features were not user-friendly. Considering the architects professional needs and expectations,

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the development of user friendly human-computer interaction is of topical importance today.

Using virtual environment to visualize design ideas from the very first initial steps, the architect is challenged to deal with perception of space, solid and void, without translations to and from a two dimensional media. At this stage we may expect innovation of design expression. The potentials of computer aided systems used for architectural design solutions in many cases are way ahead of the average users' level of competence and skills.

3D modeling, virtual buildings, single building models, and other ideas have been widely used during the last two decades. The main concept focuses on three main benefits: 1) The generation or extraction of 2D drawings from 3D building models thus improving productivity in documentation, 2) Visualization, animation, including virtual reality scenes from the same model, and 3) The use of data embedded in objects contained in the model for the purposes of generating schedules and lists of materials. However, not always these advancements have been effectively used in an everyday design practice.

Wider access of information technology (IT) and the rising involvement of architects, technical designers, engineers, and draftsmen in the 3D computer-aided design technology lead to the problems in computer literacy education. As a result we often encounter the situation when the students or professionals use the computer pell-mell, basically as a powerful 2D drafting tool. This situation is predetermined by those users which still exploit the traditional design communication methods lacking the power of 3D, 4D or even 5D design possibilities. In order to reach the architects' and engineers' intended goals, some formal specifications, standards and prototypes are required by increasing number for effective design information communication in architectural and engineering practice, including education.

ARCHITECTURAL CONCEPT DESIGN

To automate the whole architectural design process one should have a clear understanding about what should be done and what is possible to be performed with particular computer tools or media [2] during the architectural studies at the university. There are several stages in the classic process of architectural concept design. Point, shape, functional volume, and zone – these are the classic sketch elements architects use while starting to develop their initial design. Taking into account proportions and geometric relations, the outlines of the object are refined and frontal composition is determined. A massing model in a preliminary stage of the design is

dimensionally accurate summary of the fundamental exterior forms of a building. Building details are left out entirely.

In the next stage the internal spatial structure is specified in more details – walls, columns, ceilings, flat or sloped roofs identify the spatial composition. The initial lines are further transformed into planes. At this stage the corrections of initial elements are performed and first models and mock-ups are created.

In the next stage constructional elements are edited by changing their size and location in the plan view. Additional elements like vertical and horizontal communications are located in the constructional frame and volume. They organize the relationship between rooms. Besides the determination of the interior and constructional solutions the exterior is formed as well. An attempt to ignore the right sequence of these design stages will result in failure – the unity of basic elements in plan, section and elevation will fall apart.

Complex development of the facades comes next. Based on the constructive structure the architect finds several design solutions. New mock-up helps to understand better the interaction of volume and massing in the development of composition.

Corrections in the planning structure may be required in the final stage of the concept design between elevation and plan views. Only now interior and finer detail design solutions are being considered. High level visualization materials will greatly benefit the quality of project presentation. And finally the last stage will be the drawing and documentation preparation.

EFFECTIVE USE OF CAAD

AutoCAD dominates in the CAD software [3] business, oriented for civil engineers. Structural engineers have been the earliest users of design computing tools among the design professionals in the construction industry. Engineers outnumber all architects and interior designers combined by more than 20 to 1. One of the reasons for this is the AutoCAD file compatibility – today practically any CAD software can exchange DWG or DXF files.

New technologies facilitate the introduction of completely new design concepts. The 90's of the past century outlined the switch from sequential to concurrent design approach in Computer Aided Engineering. Development of interoperability standards is a complex task [4]. International Alliance for Interoperability (IAI) is leading the charge and has established software standards. To enable more data sharing, IAI developed specifications called IFC (Industry Foundation Classes). Those define building based on objects such as walls, doors and windows. Using a common object-based model instead of a drawing based project software products can more readily share the same data for different tasks.

Much higher design productivity is achieved using progressive 3D CAD systems in full scale. However, the initial stage of the introduction of every CAD is usually followed by a slight decrease in the productivity because of the training required (Fig. 1).

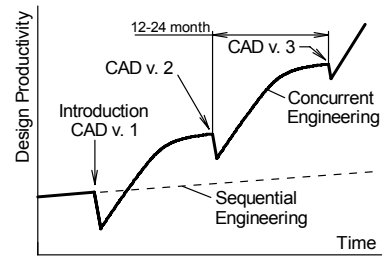


Fig. 1. Design Productivity Using Sequential Engineering and Concurrent Engineering Approach.

Only successful CAD technology innovation allows meeting the contemporary design productivity. When a new version of CAD comes out, a slight decrease is noticed because of the retraining required to study new concepts and features provided by higher performance of both the hardware and software. After 12-24 months the process is repeated again, and so on. New designers and students are facing the latest versions of CAD, and skipping all the previous ones, becoming overloaded with a huge amount of totally new information and concepts.

The preparation of the design documentation for a building project is just one of the main tasks in architectural practice. Contemporary CAAD potentials can be successfully used for preparation of highly realistic images with material textures, sun and light studies, animation and Virtual Reality (VR) presentations including computer game-based 'walk through' studies of the new design project. Some of the later tasks were not available using the conventional design method previously used. Project data during design can be shared between various software products for solving different tasks varying from architectural design, structural analysis, energy analysis, quantity estimation, code checking, and building management through all its lifecycle after the construction has been completed.

A. Introduction to CAAD

The greatest difficulty for the students while studying these issues is to acquire the three-dimensional visual skills. Nowadays students have enormous complications if these problems are considered in the old fashioned way with pencil in 'black and white' on paper when everybody has powerful computer nearby. However, the ability to successfully manipulate the fashioned design tools and media highly depends on the basic engineering graphics communication skills. Several attempts have been made to improve the teaching methods, which master the spatial perception abilities [5, 6] and develop 3D design skills using the latest achievements in information communication technologies.

The absence of professionally oriented education methodologies has lead to the situation where the students use the computer as a powerful 2D drafting tool which serves as a replacement for rotring rapidograph. Typically many students in our university work part-time in architectural firms or companies who have adopted the first CAD tools years or even decades ago. Basically the students complete the mission a

draftsman in a 'little computerized way', but basically the technology has stayed at the same conventional 'drafting design' level with limited possibilities of process automation.

The development of spatial or 3D thinking in architectural practice is extremely important and requires quite a bit of effort and time to master these skills, especially now using the new design media which are based on wide application of IT. Methods and management of introductory design education is becoming a key question in many curricula throughout the world [5, 7, 8, and 9]. Fast rate of hardware and software upgrades force the universities to spend much effort and resources on finding solutions not associated with the primary focus – education. Overcoming this obstacle is based on the development in curricula subjects the design solution approaches which do not highly depend on the level of technical equipment.

B. Competitive CAAD Software

Nowadays, the building industry requires a more productive work schedule [10]. Architects must change their design habits to adopt the new challenges. The working media has to be changed now – from plane to space, from drawing to solid model. Nevertheless, the thinking still is the same – three-dimensional. In architectural design process, we can define three phases: an investigation of the form, a technical documentation, and a presentation. Current architectural CAD systems are weak in the ability to produce first sketches – they could not be a substitute for pencil at the conceptual phase of a project.

The third generation architectural CAD [3] software successfully combines 3D modeling and 2D drafting features. One of the leaders in this class – ArchiCAD is oriented to the design of all basic architectural elements in 3D, quickly producing floor plans, elevations, and sections, providing photo-realistic images, animations and VR scenes from the same shared object model. ArchiCAD includes large project file handling capability via hotlinks, programmable database language extensions for advanced cost estimations. The new construction simulation capability could be linked to Microsoft Project documentation.

Many of the contemporary CAD systems are basically oriented on 3D model development. In architecture and building industry a concept of VR has been used for quite a while [11, 12] and this offers several benefits. Advanced IT solutions provide the opportunity to implement sophisticated distributed systems for collaborative design. Before the actual building has been constructed it is possible to test different design, construction, usability and even demolition aspects. Graphisoft, for example, uses the concept of Virtual Building (VB) model in his most famous product ArchiCAD since middle 80ies. In Autodesk products this concept is known under the name of Building Information Modeling (BIM).

Persons with different interests and competencies in the building process such as architects, installation engineers, structural engineers, electricity engineers, clients, builders, and design managers can all be brought together in a distributed design space where the VB is drafted, designed, built, and functionally evaluated. A design space created in an object-

oriented and parametric VR environment enables to simulate realistically and efficiently several variants of the form, function, construction, and use of the building yet under consideration. Therefore, nowadays even the architectural students have to start to implement the IT knowledge into their specific needs from the very first study year otherwise they might become 'the slave of the tools and not the boss' [12]. A serious misconception is when the teaching of engineering graphics is limited just to the training of how to use particular CAD software. Even worse is the case when the CAD teaching is restricted to studying only 2D.

C. Target audience analysis

The duration of bachelor studies in architecture in Riga Technical University is 7 educational periods each consisting of 16 weeks of study semester and additional 4 weeks of exam session. Compulsory subject 'Computer Applications in Architectural Design' is limited to 2 credit points and is taken in the fifth semester. In this course the students for first time are allowed to use computer aided drafting and/or design methods in their architectural design projects. The architectural students' background knowledge level is extremely diverse – from very pure knowledge till quite excellent proficiency. At the same time the overall computer literacy is increasing every year.

At the beginning of the 5th semester the students complete a questionnaire about the time when they acquired 2D computer drafting skills (Table I) and about their individual software literacy (Table II). These data allow evaluating the audience skills and better planning the course outline [13].

When the 3rd year students enrolled the university 2 years ago, 21-36 % of them already were familiar with computer aided drafting. During the first semester only 8-14 % students find spare time to learn 2D computer drafting by themselves, practically with AutoCAD. In the following semesters 68-78 % of the students have already acquired some AutoCAD drafting skills and work part-time in architectural companies.

TABLE I
TIME WHEN RTU ARCHITECTURAL STUDENTS
(5TH SEMESTER) LEARNED THEIR 2D CAD SKILLS.

Study semester	Percentage of students, %	
	Academic year	
	2004/2005	2005/2006
Before university	21	36
1 st	14	8
2 nd	24	24
3 rd	17	12
4 th	17	12
5 th	7	8

TABLE II
SOFTWARE LITERACY OF THE RTU ARCHITECTURAL STUDENTS
(5TH SEMESTER) IN ACADEMIC YEARS 2004/2005 AND 2005/2006.

Software Used in Architectural Practice	Students, familiar with software, %	
	Academic year	
	2004/2005	2005/2006
AutoCAD	78	68
ArchiCAD	51	60
Alternative CAD	11	8
CorelDraw	49	60
Adobe Photoshop	70	72
Another raster	11	16

DIGITAL MEDIA TRAINING THROUGH DRILLS

Computer aided design, as the initial step in engineering and architectural education, nowadays is of crucial importance. In this course students are supposed to acquire values, knowledge and skills which create a basis for further levels of professional education. The success in the training to model real 3D object is in the development of the talent to build it up from simple geometric primitives maintaining the required spatial relationships. It is envisaged that this approach will encourage the students to work through problems in the innovative and thoughtful ways, developing the skills they will need to cope with a rapidly changing IT world. In [5] it has been recognized that Engineering Graphics subjects should put more emphasis in spatial reasoning, since it is considered it to be a core competence for future engineers, which must gain relevance in future engineers' and architects' curricula.

The main teaching concept in the subject 'Computer Applications in Architectural Design' is to inform the students about existing complex CAAD solutions available on the market today, giving them some compulsory practical training or warm-up exercises, followed by individual design projects to develop their abilities and skills to have a good command over computer applications for architectural design tasks. The aim is to provide the students with an insight into the context and complexities of architectural design, and their future responsibilities.

A. AutoCAD or 2D Drafting Skills

Since only 7-8 % of the students by the time taking this subject are not familiar with 2D CAD drafting, it is not taught in this course. To check the students' 2D drafting skills design exercise is given as homework to be solved using any 2D CAD software. Those who are not familiar with 2D computer drawing are given time to get acquainted with the basic commands.

First exercise is the one they solved in the first semester in the course of Descriptive Geometry (Fig. 2). The 2D solution (plan view and elevation view) has to be submitted in printed form on A4 size in proper scale. The used version of CAD software should be indicated and the time required to complete the exercise has to be recorded. Total number of students questioned was 46 and 28 in the academic year 2004/2005 and 2005/2006, respectively.

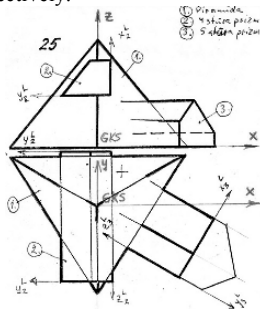


Fig. 2. Design Assignment 'Intersection of Objects' to be Solved using 4 Different CAD Techniques. (Notes are Comments in the Lecture about GDL Scripting in ArchiCAD).

Students had to self evaluate their expertise level in 2D computer drafting technique with any CAD software and in 3D modeling software ArchiCAD from 1 to 5. Competence level 1 or the basic level corresponds to the students meeting with the ArchiCAD in the class for the first time.

In each competence group an average time required to complete the exercise was calculated. The time spent for solving the 2D computer drawing exercise was found to be in close correlation with preliminary competence level in ArchiCAD (Fig. 3), except for the last academic year observed. Higher level of competence allows solving exercise 2.7 times faster. Average time required to solve 2D computer drawing for both groups and all competence levels was 62 minutes.

B. Computer Aided Sketching

Architects widely rely on sketching during their early phase of design, because sketching appears to be the most adapted mean to express and to manipulate creative ideas. Quite a long time architectural concept design sketching software resources were extremely limited. New software has recently appeared to fill the existing gap. SketchUp from Google Inc. (before @Last Software) is deceptively simple and powerful tool for creating, viewing, and modifying 3D ideas quickly and easily. It was developed to combine the elegance and spontaneity of pencil sketching with the speed and flexibility of today's digital media. Thus, 3D sketch design approach was implemented in the subject through training exercise. Students find to learn and use sketching in digital versus traditional media very easy.

The second computer aided exercise was to develop the model using SketchUp software. An average time to complete this 3D sketching exercise does not correlate with students' ArchiCAD skills (Fig. 4). On the average students spent 42 minutes to complete an individual exercise, including the learning time from multimedia tutorials. However, it was very difficult to separate the learning time from the pure time for particular design solution. Only few students were familiar with this software before classes at the university. Surprisingly, but the fact is that many architectural companies find out about power of SketchUp from the practicing students.

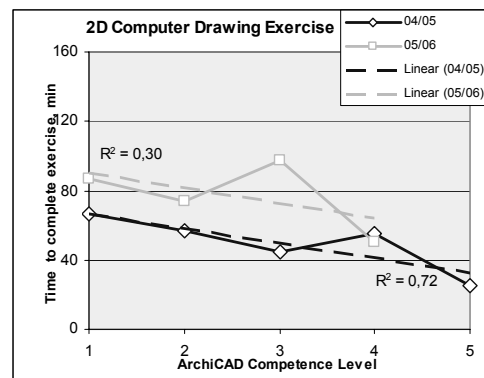


Fig. 3. Correlation between Time Spent on 2D CAD Drawing and Student's Reported ArchiCAD Competence Level.

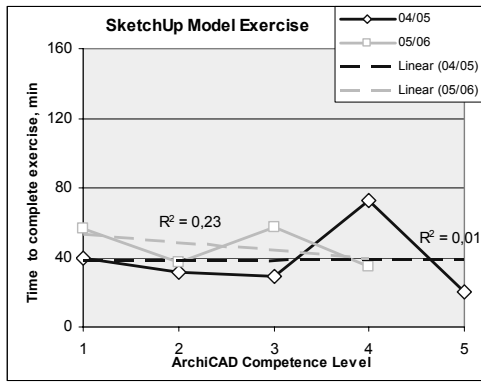


Fig. 4. Correlation Between Time Spent on SketchUp Model and Student's Reported ArchiCAD Competence Level.

C. 3D modeling with ArchiCAD

Third exercise was the development of 3D modeling skills using newly introduced to many of the students ArchiCAD software. After overview lecture about basic principles of design and instruments used, students were required to practice individually. Only three basic 3D tools – slabs, walls and roofs – were required to master the basic spatial modeling skills and to complete the same exercise discussed before. The average time to solve the exercise was 69 minutes. About 28 % of the students reported their expertise level higher than introductory.

The students reporting the 5th level of competence solved this exercise within 7 minutes, while for the beginners and users with the 2nd competence level it took approximately 113 and 110 minutes, correspondingly. Strong linear correlation was found between the time to complete this exercise and competence level for last two academic years (Fig. 5). This graph clearly demonstrates the importance of CAD training in effective use of software.

D. Programming Skills in GDL Language

The fourth exercise was devoted to the Geometric Description Language or GDL which is a programming language inside ArchiCAD. It is very easy to learn BASIC

type programming language having very close relations with descriptive geometry problem solutions. Some algebraic knowledge is required as well. In order to bridge the individual concepts and processes of multiple design disciplines, intensive cross-disciplinary communication and information exchange starting from the very early stages of design is necessary. This quest for integration has become one of the key issues in building design practice today.

About six academic hours was spent on GDL lectures with numerous demonstrations of practical examples. To prove the students' understanding of the subject the same assignment exercise has to be completed using GDL language. The skills mastered to write the script (program) includes operation with basic geometric primitives – prisms and pyramids – and coordinate system manipulations or transformations. This was the most difficult task for the students (Fig. 6). The average time required to complete the exercise was 112 minutes. Only the students reporting the highest level of competence in ArchiCAD solved the exercise on average in 40 minutes which is 2.8 times faster than the rest of them.

Introductory design project was aimed to develop the proficiency in representing the surrounding world through the lens of specialized computer aided solutions. The ability to abstract the reality through the associative patterns is being developed through the design project "Unlimited possibilities with limited resources". The main goal is to produce a free choice composition following several rules. Design rules are limited with the use of only some selected features from 3D software. The limitations have been implied intentionally to force the students think non-traditional way. The computer in this case serves only as a simple but powerful instrument. Additional unlimited resources allowed to include in the project are color, texture, light, visualization and animation. The students have to develop professional thinking during this compositional design training using ArchiCAD. The task is to facilitate a personally innovative way of employing the computer as an analytical or communicative tool in the design. The project has to be presented as two scene renderings on one A4 size page, submitted in digital form and supplemented by animation movie.

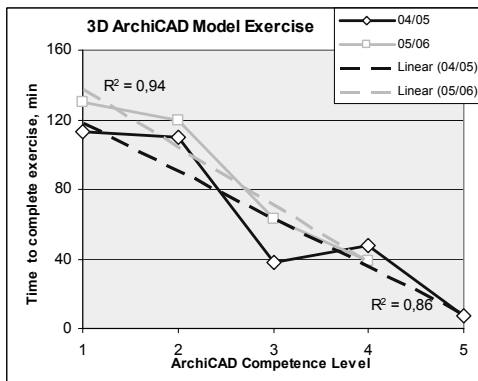


Fig. 5. Correlation Between Time Spent on 3D ArchiCAD Model and Student's Reported ArchiCAD Competence Level.

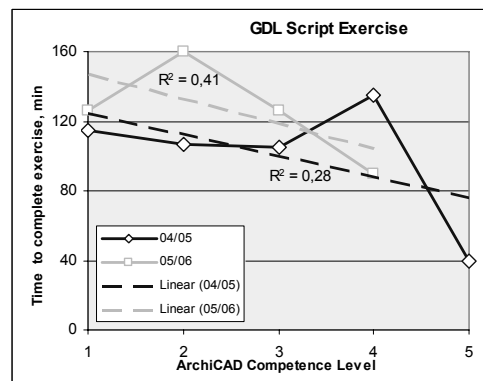


Fig. 6. Correlation Between Time Spent on GDL Script and Student's Reported ArchiCAD Competence Level.

E. Advanced Studies

Digital imaging, digital painting, alternative 3D modeling, 3D animation movies or walk-through, VR, 3D printing are issues covered in further studies. Majority of these questions are covered only theoretically, mainly due to limited hardware and licensed software resources. The subject content is being constantly revised each year to allow for the ever changing situation in CAAD tendencies in the world and taking into account the existing potentials. Several individual small scale design projects have to be elaborated using available 3D modeling software. Final project in the course has to be prepared on A1 size digital poster demonstrating computer aided technology skills acquired in this course which can later be used in architectural practice. The project has to be submitted in platform independent format, e.g. PDF format. This format is widely used in design communication in contemporary information technology applications. For the observation one can use free software Adobe Reader, the latest versions of which supports inclusion in the documents interactive 3D model information and movies.

In an exam besides the theoretical question and practical exercise the students have to explain their opinions about the different computer aided solutions they get familiar with and the technologies used in the companies they get practice.

CONCLUSIONS

CAAD innovations are more effective when taught from the very beginning in architectural syllabus, parallel with the conventional design methods. Gradual teaching, while students' design education advances, seems to be better, because it is difficult to maintain the students' motivation in class by just practicing the tools and working with separate design examples.

A timekeeping test proved that proficient use of CAD software can provide to the trained users considerable time saving which, for the solving of particular exercise among the students, was up to 16-18 times. The same degree of diversity in the CAD skills among the students brings up to the educators additional workload in order to keep the class attention.

The CAAD subject content should be reviewed and revised each year in order to keep the students informed about emerging trends in the fast changing IT world, that are applicable to architectural, technical, and interior design.

There is a need to shift the thinking process of today's practice towards one that is more comprehensive in nature. Design studio should collaborate with specialized CAD laboratories which facilitate more hands-on-applications as it is already practiced in western high-tech nations outside the academic environment.

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Learning Two-Dimensional Physics and Mathematics through their Applications in Robotic Manipulators

M. Ali Yousuf, V. de la Cueva Hernández and R. Montúfar Chaveznava

Robotics, Automation and Educational Technology Research Group (GIRATE)

Tecnologico de Monterrey - Campus Santa Fe,

Avenida Carlos Lazo 100, Colonia Santa Fe, Delegación Álvaro Obregón, CP 01389, México DF, México

Muhammad.Ali.Yousuf@itesm.mx

Abstract-We present our experiences with the use of parallel robotic manipulators in the learning of mathematics at high school and beginning undergraduate level. The appreciation of the applications of mathematics developed in this process helps students in all the basic courses taught at this level including physics, mathematics, statics & dynamics, etc.

I. INTRODUCTION

Students generally find it difficult to understand the utility of “advanced” topics in mathematics¹ when they encounter them first in their professional education. The list of topics includes vectors, trigonometry, matrices and determinants, and calculus. The subject has always been a challenge for the students at engineering institutes and universities. Most of the students at such places come with a very direct and applied approach to problem solving and find it difficult to take a course where the professor shows them how to solve equations at a purely abstract level with no immediate application in mind. Even the “standard” method of active learning, where students are involved in their own learning through class discussions and group problem solving, fails. Due to the heavy use of animations and movies in their life, young students have lost their ability to visualize things correctly. This was possible for our generation a few decades ago for reasons quite understandable. For the younger generation, a man can easily fly, a fish can talk and a cockroach can be as big as a human. Why not? They see such things every day on television or on their laptops. These students need an extra effort to link their thinking to the real world as it exists.

Though the subject has received considerable attention, there is still room for improvement. A reasonably large amount of literature exists on the use of software to teach and explain mathematical concepts. These help a lot to many students, but still leave the big question open: are these equations really meant for something real. To partially solve this problem we have attempted to integrate robotic manipulators into mathematics courses. Our experience

shows a clear improvement in student involvement and motivation.

The plan of the paper is as follows. First we review the current literature in section II. In the same section we also review active learning. We discuss the robots and mathematics in section III. Conclusions are given in section IV.

II. REVIEW OF THE CURRENT LITERATURE

An extensive amount of work has been done in the use of standard mathematical software packages for understanding mathematics. This includes famous systems like Mathematica, Maple, Drive or MATLAB or their extensions. However, for the new breed of engineering students the use of software and / or numerical technique is not rewarding. The “active learning” method used by our groups has its roots in many years of research by other groups. The approach [1] can be divided into two parts:

- a. The experience of: Doing and Observing
- b. A dialogue with: Self and Others

The model is fairly general and though can be applied to all sorts of courses; it needs fine adjustments depending upon the subject matter, level of the course, and other sociological factors. It can be achieved in various ways including, but not limited to, case studies, field trips, use of games, computer demonstrations, audio visual materials, lab presentations, project work, etc. The model has also been applied successfully to the teaching of mathematics. Generally in this model a mathematical software package is employed. It requires students to ‘draw’ the solutions and ‘observe’ the effect of changes in various parameters. This is supplemented by a series of questions to individual students and class discussions.

The idea of using demonstrations as teaching aids has been explored extensively in the recent years [2-5]. Many of the researches have tried to include a project-oriented approach to the teaching of engineering subjects [6]. Though we have found few papers talking directly of demonstrations in mathematics, many of the physics papers end-up discussing both physics and mathematics learning at the same time. This approach has the added benefit of allowing students to go out and seek information on their own.

¹ Advanced mathematics here means mathematics for the beginning students at professional level for whom even matrices and calculus are advanced topics.

Mathematics is a major theme in the design of mobile robotics and our group has gained some experience in this area. There is a vast body of literature available on the use of these robots in teaching at various levels, including school students. Though mobile robots help a lot in motivating students, we have noticed that the applications of mathematics in industrial robotic manipulators are even more vivid and easy to understand. Hence we have made an attempt to exemplify these applications to junior students using a three dimensional robotic manipulator. We also try to explain the vast variety of applications of these manipulators, and opportunities for further research and development within our group.

During the lecture sessions, we also try to provide information related to the importance and applicability of parallel robotic manipulators. The origin of parallel mechanisms can be traced back to the first practical machine introduced by Gough [7]. Parallel manipulators can be classified as planar, spherical, or spatial manipulators in accordance with their motion characteristics. Because of this they can be applied to solve a large variety of industrial problems. In particular, they have found their way into industries requiring high precision, speed and stability. They have been used in applications like airplane simulators [8], adjustable articulated trusses [9], mining machines [10], pointing devices [11], machining centers [12], and even walking machines [13].

Students complain about various aspects of physics and mathematics that are not clear to them as to why they are important? A common problem is with the bunch of trigonometric identities which seem to serve no other purpose than solving the problems assigned by the teacher. Determinants appear to be a big hurdle too. They "seem" to serve no purpose in real life. To remedy the situation we have chosen a simple, parallel robotic manipulator. The system chosen for this purpose is a RRR (three revolute joints) type robotic manipulator with two translational (x and y) and one rotational (ϕ) degrees of freedom. For a detailed discussion of it, the reader is referred to Ref [14]. A simulation of the same using MATLAB is also available [15].

Obviously, this is not the first attempt of its kind. An extremely large body of literature exists in this area. For example, in [16] authors have tried to integrate robotics research into course and project work in order to enhance and update curricular activities. Their educational goals were: Give students hands-on experience with real problems, give them experience in understanding and implementing principles from primary research literature², give them confidence in their ability and help them develop

teamwork skills. Reference [17] focuses on math education using programming of robots. Interestingly enough, they focus attention to school students and have developed a system specifically that helps in teaching mathematics to them. The use of robots in enhancing the quality of education at a university level, using microcontroller based robots, has been discussed in [18] and [19]. In Ref [18] students at sophomore level are being involved in robotic projects. They design, build and test their robots themselves and that helps them later in their education. The authors of [20] use Lego robots to teach elementary science to school students. Reference [21] has gone to the level of teaching control to eight graders in public schools. This program, working under the G-12 program of NSF has designed and implemented instructional robotics modules for school students. The starting point of their work was the observation that science and mathematics courses begin to focus on applications starting from 8th grade and hence that is the level to attack and modify.

However, little has been done in the use of industrial robotic manipulators in teaching science. To some extent this is due to the non-attractive nature of their applications which do not get attention of younger generation. However, in our experience, they provide a better and cleaner route to learning mathematics and physics.

III. ROBOTS AND MATHEMATICS

Our system is shown in the Fig 1. The central black part is the actuator which can be located at any point (x, y, ϕ) and can additionally contain tools to manipulate objects. The three dots at the extreme ends of the triangle contain servo motors to control the movements³.

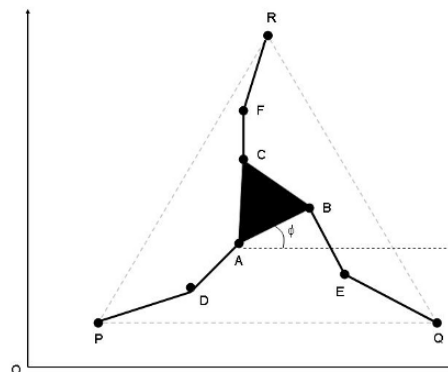


Fig 1: Schematic Diagram of the robotic manipulator.

² Not addressed by our group.

³ The model used in the demonstrations has been made without using servo motors to reduce the complexity of design.

In this standard configuration, the points P , Q and R are considered to be fixed in space and the motors are located at these points to make it move in a plane. The points A , B , and C define the moving platform. Three limbs connect the moving platform to the base. Each limb consists of two links connected by a revolute joint. Thus the mechanism consists of eight links and nine revolute joints. It can be shown, [11] that the mechanism has three degrees of freedom. The moving platform is considered as the output link and the links PD , QE , and RF act as the input links. In this configuration all the actuators are installed on the fixed base. The wooden model of the robot is shown in Fig. 2.

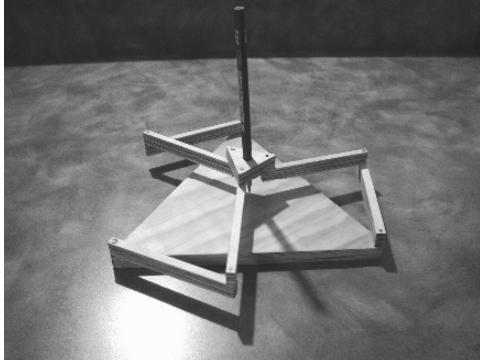


Fig 2: Wooden model of the robotic manipulator.

To demonstrate various branches of mathematics, the kinematics equations of the robot are first written in **vector** form and later transformed into component form using **trigonometry**. **Derivatives** are needed to calculate the joint velocities. Since the robot has three ‘legs’ with similar equations, these can be put in the form of a **matrix**. The **determinant** of this matrix gives us information about the ‘efficiency’ of the robot. Finally, three input variables $(\theta_1, \theta_2, \theta_3)$ control the three output variables (x, y, ϕ_2) and this is another crucial concept in the **change of variables** whose utility becomes clear in this example. This is essentially all the mathematics they learn in their physics courses too with two dimensional motion, and rotations in the xy -plane. Hence we find it to be an ideal system for motivating students in learning mathematics. Let’s see the various areas of mathematics as they appear in the study of parallel manipulators.

Vectors:

We can then write the location of the moving platform in terms of three coordinates – the location of a point on the platform as a pair (x_A, y_A) , and an orientation angle ϕ_2 . First we demonstrate the applications of vectors. From the

geometry of the figure we can write a vector loop equation for leg 1 (closest to the origin) as:

$$\overline{OA} = \overline{OP} + \overline{PD} + \overline{DA}$$

Similar equations exist for the other loops:

$$\overline{OB} = \overline{OQ} + \overline{QE} + \overline{EB}$$

$$\overline{OC} = \overline{OR} + \overline{RF} + \overline{FC}$$

Trigonometry:

The first equation written above can also be written in terms of components. Notice that \overline{OA} is the vector to the point (x_A, y_A) . If the angle between the x -axis and the line PD is θ_1 , and the angle between the line PD and DA is ψ_1 , we can write:

$$x_A = x_P + a \cos \theta_1 + a \cos(\theta_1 + \psi_1)$$

$$y_A = y_P + a \sin \theta_1 + a \sin(\theta_1 + \psi_1)$$

A further application of trigonometry can be seen at the step where we try to eliminate the internal angle ψ_1 . These equations are to be solved for so that we only have one angle, θ_1 . Thus we rewrite the equations as:

$$x_A - x_P - a \cos \theta_1 = a \cos(\theta_1 + \psi_1)$$

$$y_A - y_P - a \sin \theta_1 = a \sin(\theta_1 + \psi_1)$$

Squaring and adding we get:

$$(x_A - x_P - a \cos \theta_1)^2 + (y_A - y_P - a \sin \theta_1)^2 = a^2$$

Where we have used the famous trigonometric identity: $\sin^2 \alpha + \cos^2 \alpha = 1$.

Differential Calculus:

Knowing the angles, however, is not sufficient. We need more information in order to control the robot. Hence, for example, we need the angular velocity to be applied by servo motors at points P , Q and R . That means calculating the first derivative of θ_1 with respect to t , or $d\theta_1 / dt$. This quantity is also written as ω_{1z} , that is, the angular velocity of the first servo along the z -axis. Similar equations exist for the two other servos at points Q and R . Since these are very complicated equations for students at this level, we refrain from writing them in component form. The interested reader may see [11] for a detailed discussion.

Matrices:

Finally, though we will not show the details of the calculations (these are not shown to the students either), we can write the three equations for $d\theta_1/dt, d\theta_2/dt, d\theta_3/dt$, in a compact matrix form.

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix} \begin{pmatrix} dx/dt \\ dy/dt \\ d\phi/dt \end{pmatrix} = \begin{pmatrix} d_{11} & 0 & 0 \\ 0 & d_{22} & 0 \\ 0 & 0 & d_{33} \end{pmatrix} \begin{pmatrix} d\theta_1/dt \\ d\theta_2/dt \\ d\theta_3/dt \end{pmatrix}$$

The values of the matrix elements a_{ij} and d_{ij} are not given due to their lengthy expressions but the students are made aware of their functional dependence. Both of these are functions of the leg lengths of various legs (or links) like PD and DA. They also depend on the size of the moving actuator (the black triangle in the centre). Furthermore, students can see that the inverse of the matrix \mathbf{a} has to be calculated and if the determinant turns out to be zero, the operation cannot simply be performed. The same thing happens with the matrix \mathbf{d} on the right hand side.

Besides the topics covered here, we have also used the same robot to explain concepts like angular acceleration, torque and friction. In this setting students find it easy to understand the application of theoretical concepts. Some times students are also asked to develop low cost, working models of this robot using plastic tubes, pins and cardboard. This helps them in understanding the functioning of the system.

IV. CONCLUSIONS AND FUTURE WORK

We have developed a technique for the teaching of mathematics which depends on their state-of-the-art applications. We have found that the student interest increases when they can see the applications. In our work certain branches of mathematics have not yet been explored or have been explored only partially. For example, integral calculus and analytic geometry still need attention. We are working in this direction too and shall report our developments in a forthcoming paper.

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A University e-learning and Service Providing System: A Case Study

Nael Hirzallah, Sandrella Mahjoub
Computer Center, Applied Science University, Amman, Jordan
drnael@hirzallah.com, sandra@asu.edu.jo

Abstract-This paper lists a number of essential services and information requests that are expected to be offered in any e-system intended to assist the educational process of any educational institute. The way the list is presented is through a system that has actually been developed and tested in some university. The goal of such a system is to utilize the latest practice in responding to the needs of technological teachers and trainers with a focus in providing quality services to its students and staff. The services and requests are categorized into a number of modules: e-courses, grading, assignments, communications, and supervision. The paper will summarize most of the services listed, but with some level of details, it will focus on the e-learning part. With a view of the future, the paper will also include review of the challenges and opportunities that continue to exist in technological teacher development.

I. INTRODUCTION

For the last couple of years we have heard much of how e-learning has failed to live up to its long term promises. However, on the other hand, there are many institutions and businesses that have been successfully deploying e-learning over a significant period of time, and have found ways of engaging learners with them in that process.

e-learning is not limited to school and university students, but also to industry where companies may get involved in educating their employees in certain procedures or products.

Hundreds of institutions and businesses (as stated in Ref.[1]) are using e-learning. Current e-learning platforms are primarily concerned with basic software features like whiteboards, discussion questions, chat, etc. However, technology can be combined with education principles to create an advanced form of learning that extends beyond discussion questions and chat. While these applications are helpful for communicating many concepts, they cannot be considered as comprehensive tools for education.

While the focus of e-learning systems remains within educational institutions, a list of essential services and information requests is presented in this paper through a non-commercially developed system that is also used in a university.

The bilingual system was named *e-Jameah*, after the Arabic work for "e-University". It presented a new set of services devoted to e-learning. Technology-based learning is already changing the way we teach and learn. The system involves designing and presenting online courses, providing

communications tool, and many more services to various roles of users.

Thus, the presented ideas that are considered as Add-on's to any e-learning system are being discussed within the context of an already implemented and tested system using these ideas. That system is not viewed as a prototype but it is actually used at the authors' university.

II. OVERVIEW

e-learning has become one of the hottest field in which both the industry and researchers are competing in through new ideas and tools. Many systems are already available in the market and being used by many institutions as an e-learning platform. Although, as clearly mentioned by their vendors, they are not true e-learning platform, that is, providing A-Z tools for students and instructors to accomplish their goals without the need to sit in a real classroom, but many institutions who are using these are claiming it is. This may arise due to the lack of full understanding to an e-learning term.

In this section we present some work in the literature versus couple of systems already available in the market; one of which is an Open-Source.

Cedefop's European Training Village (ETV) Ref. [2] has introduced new, improved, user-friendly web services in the field of electronic learning. As modern advances in technology make it possible to transform traditional teaching methods, the ETV's web pages are geared towards the construction of a new information base for all professionals in the field of education and towards the development of a community of practice.

Through the pages related to e-learning, users will be able to search an extensive network of information for services and activities, such as opportunities in e-learning, surveys, general information, a news centre, and daily issues in electronic learning.

Many argue that the communication between trainers and trainees or instructors and students is an essential part of the e-learning process. Although we don't truly argue against this claim, but among them are those who go an extra step in claiming that having an online meeting software might be enough to grant the institution an e-learning provider title. This, however, we clearly argue against through our presentation to the number of services that e-Jameah is offering. Furthermore, many of such software have major shortcomings that can severely limit the adoption of web

collaboration in organizations as a source of e-learning. One such example is NetMeeting produced by Microsoft. Although Microsoft has discontinued the product Ref. [3] but it has initially played an important role in the early adoption of web conferencing, until the second generation web collaboration products and services with very competitive flat-rate pricing were introduced in the market.

Moodle, Ref. [4], is a software package for producing internet-based courses and web sites. The word Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment. It is an ongoing development project designed to support a social constructionist framework of education. Moodle is provided freely as Open Source software (under the GNU Public License). The advantage of being Open Source not only gives you the right to use and modify it, but also modifications and enhancements may be shared by all. This often leads to insight and creativity. Thus, in short period of time, Moodle has reached to a state where many of the features wish lists, that most educational institutes have, are already being implemented or under development. Such features include: Question engine, Assignment types, Activity modules, Activity modules, and Course formats. Moodle is built using PHP technology, and can support many types of database (particularly MySQL).

However, there are some concerns about using PHP for enterprise applications. Large enterprises do not entertain PHP due to the lack of support or a throat to grab when things can't be made to work in a certain amount of time. The single driving force behind most companies' decisions to move forward with *any* platform, language, software, and hardware product boils down to support, accountability, and SLAs wrapped around these things. In fact, these companies spend more money on support agreements than they do on actual software. Besides, there are not many "developers" or even "architects" that are good in those roles and do PHP. The enterprise ready talent pool for PHP is small.

Moreover, many PHP developers believe that PHP is significantly short in providing a good framework for the best practices of architecting the application.

However and on the other hand, many still believes that PHP is a really great language. Furthermore, to be fair though, Yahoo! and wikipedia uses PHP, so does IBM, although they use Java (JSP, struts) a lot.

Blackboard software, yet another similar system, is used to manage e-learning (*Blackboard Academic Suite*), transaction processing and e-commerce (*Blackboard Commerce Suite*), and online communities. The Blackboard Academic Suite is flexible, extensible, and will enable you to:

- Teach using advanced tools
- Build community across the campus
- Share educational content, and

Among the features that the Blackboard Academic Suite provides to the instructors is the ability to create and manage course content, utilize publisher content, evaluate performance and communicate with students.

Although Blackboard software is a non Open Source system, the company provides an open architecture, called

Building Blocks that can be used to extend the functionality of Blackboard products.

However, Blackboard is available in the market at a price considered by many institutions as an expensive system to use. Furthermore, the content or lectures developed using such systems, in most cases, cannot be used elsewhere; thus, leaving the institution under a long term agreement with the vendors of these systems.

e-Jameah, discussed in this paper, on the other hand, provides not only the basic e-learning features provided by these systems, but also additional features and user roles that is believed to complement the services provided for all sort of parties related to an educational institute. Furthermore, the courses content, used by the system presented are developed using SMIL language that is available to all and played by many available players such as RealPlayer of RealNetworks Solutions. Furthermore, its target is to be available as an Open-Source system once a complete year round test is performed.

III. THE SYSTEM: E-JAMEAH

e-Jameah is a system that both authors were involved in its development process. Although it provides modules for general e-learning purposes, but it currently addresses a university environment. When first went live in 2002, it was considered as a tool used by both students and instructors to view transcripts and some basic information, and not yet viewed as an e-learning system. However, since then enhancements were made till it became an essential part in the education process at the university. Both Students and instructors dependency were ramped up especially after introducing the e-courses module.

e-Jameah is a combination of modules that may run separately or be integrated to provide a group of services to the students, academic staff, registrar, students' sponsors, and administration. Although the features set of the system is quite long, but in this paper we will summarize the essential ones, yet, focusing on those that are either considered innovative or closely related to the e-learning field.

Fig. 1 expresses a high level view to the different modules of the system and the dependency relationships among them.

Each module is responsible for providing a set of features through its sub-modules that will be briefed in this section. e-courses module will be later discussed in a little more details in the following section:

Messaging Module

- *Announcements:* Allows messages postings by instructors, heads of departments (HOD's), deans, and the president addressing the recipients within the domain of each one's privilege. Recipients could be either individuals, such as a student or a staff member, or groups of classes, departments or faculties.

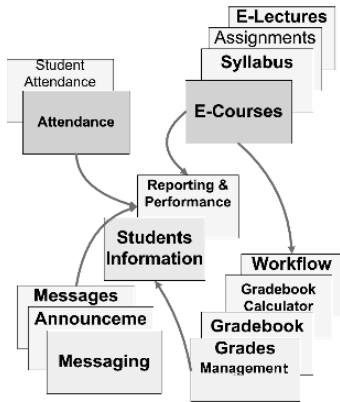


Fig.1. e-Jameah Modules

- **Messages:** Allows communications between students and their instructors, similar to an email system. However, the address book is dynamically created through the course registration process.

Grades Management

- **Gradebook:** Stores student results and offers support for custom grading, grade weighting, item analysis and multiple gradebook views.
- **Gradebook Calculator:** Calculates grades based on student activities and displays special students reports to instructors.
- **Workflow** provides users with the ability to route content, such as class marks by instructors, to others for review or approval.

Students Information

- **Reporting and Performance:** Provides a view of student progress based on marks, warnings, and instructors feedback on them (similar to eBay seller/buyer positive and negative feedback), and indicates whether students have reviewed specific content items or not.

Attendance

- **Student attendance:** Record students attendance at lectures, lab classes etc, and then produce attendance reports.

The Student Information Module is considered the central Module where most of the information is shared. For instance, the e-courses module extracts the students ID's who are registered in a specific course to allow them to enter and view both the assignments as well as the lectures posted. Whereas Syllabuses are available to whoever has access to the system.

e-Jameah offers various services for various users depending on the role the user is playing. The eight roles offered by the system are: Student, Instructor, HOD, Dean, Registrar, Advisor, Embassy (or sponsor), and administrator. They are also depicted in Fig. 2.

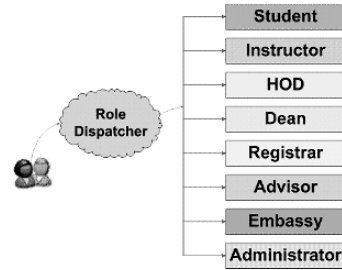


Fig.2. Users Roles

For instance, the administrator services include (but not limited to) accounts creation and manipulation, modules scheduling, Data manipulation, and backup tools; while Dean's services include monitor class occupancy, post announcements to faculty, review and approve grades, and view class communications statistics.

IV. E-COURSES

This module represents the core of the e-learning part of the system aside from the communication, messaging and grading modules. Once this module was launched, the dependency on the system by students and instructors became high. It opened the door for the university to start thinking in distance learning. However, with the current setup of the e-courses, the student could get what he/she needs to study, do the proper assignments and sit for the scheduled exams offered all through the module. The module is composed of four sub-modules: e-lectures, Assignments, ExamOnline, and Syllabus. While the Syllabus sub-module is mainly a tool to enter, update and view a course syllabus, the other sub-modules are a little more complicated, yet easy to use.

A. e-lectures

While the core of e-Jameah system is the e-courses module, the core of this module is the e-lectures sub-module. In this sub-module the instructors are given a tool to easily generate lectures that can be put online. Similar work has been done in the literature such as Ref. [5] and Ref. [6], but the difficulty was having popular players be able to play back their outcome. Lectures may include video, audio, slides and animations; and the need for these lectures be viewed by popular players is as well important. Initially, this presented two challenges. The first was to have an authoring tool that does not need special training, and the second was having the outcome format be played back by popular applications or Add-on's to popular internet browsers.

SMIL, Synchronized Multimedia Integration Language Ref. [7], a W3C Recommendation, was the choice of the language to package an e-lecture. SMIL allows integrating a set of independent multimedia objects into a synchronized multimedia presentation. SMIL, explained in Ref. [4],

although it is beyond the scope of this paper to be detailed, but as a quick introduction, it allows the authors to:

1. describe the temporal behavior of the presentation,
2. describe the layout of the presentation on a screen
3. associate hyperlinks with media objects

Thus, by describing the regions that will compose the layout, then filling those with images, hyperlinks or video as needed, and finally defining a sequence of changes in one or more of these regions, the outcome would be a complete lecture. The following is a sample of the paragraphs composing a sequence. It specifies an image, named Slide1.JPG, to be displayed at a specific time for a specific duration in a specific region, and finally using a fade-in transitioning.

```
<par
dur="00:18" begin="00:15" id="par_01">

</par>
```

The e-lecture used by e-Jameah, is composed of four regions specified as follows: (refer to Fig. 3):

1. Video showing the instructor in wide view or a close up view (including Audio)
2. Images showing the slides, animations, and instructor on-the-fly notes
3. Table of contents as hyperlinks
4. Logo of the university and copy right notes.

The easy approach to create such an e-lecture was to combine the video and Audio captured by a camera and a microphone with a timed PowerPoint presentation slides, saved as images and timestamps, using SMIL. Combining these manually is a time consuming process which usually ends up using trial and error fashion to accurately synchronize the audio with images.

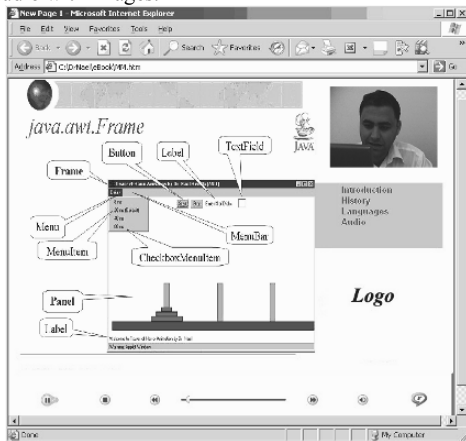


Fig. 3. An e-lecture sample

Therefore, the need for a tool not only to automate this process but also to catch animations and instructors on-the-fly notes became a must. On-the-fly notes are defined to be any high lightening, sketches, text additions, etc... entered by the presenter during the presentation. In PowerPoint, these can be accessed by clicking the right-mouse button during the Slide Show mode and selecting the Pointer Options.

For that, we've proposed and implemented a very simple algorithm that periodically compares the slides presented, say every 1/3 of a second. Upon detecting a difference, the screen is captured as an image with its timestamp. While most animations and instructors notes are triggered by a mouse click or keyboard events, the algorithm performs frames comparison only at such events; reducing the cost (processing power) needed over comparing all frames throughout the presentation. Fig. 4 depicts the algorithm which we call as e-lecture Authoring (EA) algorithm.

For an instructor to produce an e-lecture, it is assumed that a presentation (say a PowerPoint one) is ready in SlideShow mode; Once the EA tool starts, Video and audio starts being captured from the camera and microphone feed, while the algorithm starts listening to events and comparing frames.

After, say 3 seconds, the first screen shot (representing the first Slide) is captured. Upon a keyboard or a mouse event, a number of screenshots per second undergo frame comparison. Should a difference be detected, then these screenshots are being saved along with their timestamps. Once the frame settles with no changes for another period of time, the algorithm rests.

Finally, within the "Generate SMIL file" block of the flow chart, in Fig. 4, the tool presents the resulted images allowing the author to enter text as titles for selected images, before the system composes the targeted SMIL file. This file packages the lecture as presented; missing neither on-the-fly notes nor animations.

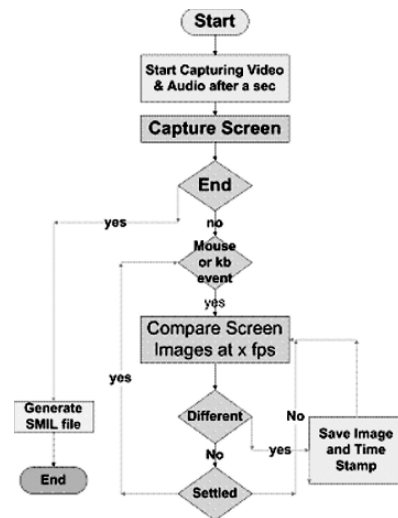


Fig. 4 e-lecture Authoring Algorithm

Fig. 4 shows an e-lecture being played by RealPlayer plugin, a RealNetworks application. The students are offered to stream and view e-lectures through their normal browsers within Add-on components. One of the advantages of such e-lecture format is that it is hard to download the complete package, thus preventing e-lectures from free distributions, unless of course, when it is explicitly offered in zipped files.

B. Assignments and Exam Online

The Assignment sub-module of the e-courses allows the instructors to create assignment items through which students can submit their responses. These assignments are only displayed during instructor-specified start and end dates and times.

The instructors will be able to auto track the students who opened the assignments and who did submitted their solutions. Instructors may evaluate the answers and assign marks if needed. These marks will then be used by the Grades Management Module. Multiple choice and/or True/False questions may be offered to students through ExamOnline.

The ExamOnline sub-module allows instructors to hold exams online serving a real test, a practice test, or as an assignment. Fig. 5 illustrates the steps to setup one. First the instructor enters multiple and/or true or false questions through the excel uploading feature, or by creating one question at a time. These questions and answers are saved in a database under the category of the instructor course name selected. The system allows figures displaying for each question if needed. The instructor then creates a test by grouping a number of questions from the database together, using keyword and level of difficulty search feature. Third, a session should be created which defines the type of the exam (real, practice or assignment), the time and duration, the group of questions to be provided, and the group of students who will be sitting for the exam. The student information is being imported from the student's information module. Finally, the instructor activates the session which will regenerate passwords to students and resets their flags to Active (this flag will be set once the student completes the exam).

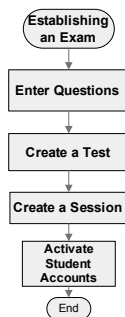


Fig.5. Steps to create an Online Exam

Among the features that ExamOnline provides, is the ability to randomly order not only the questions but also the answers. This gives the feeling to students that there are an unlimited number of forms per test.

Furthermore, the system generates statistical reports on the performance of the students over time on a specific course or for all courses the student registers for.

V. PLATFORM USED

The system was built using Java Platform, Enterprise Edition or Java EE for developing and running distributed multitier architecture. The database used is Oracle. One of the benefits of Java EE as a platform is that it is possible to get started with little or no cost. The Java EE implementation from Sun Microsystems can be downloaded for free, and there are a great many open source tools available to extend the platform or to simplify development.

VI. RESULTS AND ANALYSIS

Although we have summarized hundreds of features of the e-Jameah system using just few lines per module; however, the focus was on the e-courses module that has proved to be an essential part in the e-learning process at ASU. Dozens of lectures have been developed and many more are produced monthly.

As far as e-lectures is concerned, a 20 min lecture is found typically to include approximately 40 images representing around 25 slides. The slides of dimensions of 960x720 (although could be set to smaller) and using JPEG compression typically do not exceed 4MByte. The video with a dimension of 160x120 captured at a Max Stream Bit Rate of 32.0 Kbps and Audio using RealAudio SureStream Audio at 22050 Khz typically around 32 Mbyte. Thus the whole 20 min lecture sized around 40Mbyte of streaming data.

VII. CONCLUSION

e-Jameah facilitated and supported much of the academic processes including the education. Students are being served from generating transcripts to getting lectures to communicating with colleagues and instructors to sitting for exams through an online system. In addition to students, the various types of parties involved in the education process from parents to instructors to sponsors to registrar have also found themselves deeply involved in this system. e-Jameah has elevated the quality of education in the authors' university over the past years, and yet continues to do so by more and more features being developed.

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Computer-aided Building Design Education: Simulating the Design Process in a Project-Based Learning Curriculum

Neander F. Silva

&

Ecilamar M. Lima

Universidade de Brasilia

Faculdade de Arquitetura e Urbanismo

neander@unb.br, ecilamar@unb.br

Abstract - Teaching computer-aided building design (CABD) in a project-based learning environment is an idea derived from the broader problem-based learning movement. However, a project-based learning curriculum has rarely been implemented in building design education, let alone in CABD. The idea of teaching CABD through design-based approaches has been increasingly adopted over the past 20 years. However, most of the resulting experiments have been limited to specific courses within larger programmes. This approach has rarely affected a dedicated CABD curriculum. The development and implementation of a feasible project-based learning CABD curriculum is described in this paper. In this programme the emphasis is placed on the building aspects and/or objectives of the design process rather than on the different products of the design phases or even on software categories.

I. INTRODUCTION

The use of computers in building design is a common place nowadays among architects. However, most of them still use computers in the same way they used the previous technologies. In other words, they use the computer as a mere design documentation tool or, at best, as a presentation tool. They do not take advantage of the various new possibilities offered by this new technology.

We regard as the main cause of this problem the way in which most architects learned and still learn to use computers in their professional activities. Most schools still stress design documentation rather than design exploration, analysis and synthesis when it comes to teach computer-aided building design, CABD.

For this reason we started investigating a way of teaching CABD that could promote the use of computers as design tools rather than documentation tools. We assumed that this should be somehow based on an approach that would simulate the very design exploration, analysis and synthesis. In other words, it should be a design-based approach.

The assumption that teaching Computer-Aided Building Design, CABD, by simulating true-to-life design tasks will bring better learning is not new. It is neither specific to CABD teaching nor to building design education. This assumption actually stems from the broader movement of problem-based learning, which started more 30 years ago in medical schools of North America and spread into many professional fields [1]. Problem-based learning has been specialized into Project-Based Learning in the areas of building design and architectural design [2]. In this paper whenever we use the abbreviation PBL we will be referring to Project-Based Learning rather than to the broader problem-based learning approach.

The task of defining problem-based learning precisely is not an easy one. There are many possible strands and the boundaries with other approaches are often blurred. For the sake of the argument presented in this paper we take it as defined in [1]: “an approach to education” where teaching takes place by “presenting the problem as a simulation of professional practice or a real life situation”. However, we do not subscribe entirely to all its claimed features, but we adopt the one which we believe is the most relevant, not only for

CABD teaching, but also for architectural education. Among the most contentious issues of PBL is the idea that teaching should always start and develop through presenting problems to the students [3] rather than concepts. Although we seek a problem-based learning oriented approach at our school, we do not agree with this dogmatic requirement and we insist in the need for hybridisation with traditional teaching methods such as lectures, tutorials and essays.

Building design education, in contrast with many other professional fields, contains the most relevant PBL feature: the simulation of professional practice through the design studio. This feature is derived from the origins of architectural education in tutelage and apprenticeship to a practitioner. However, PBL in building design courses is usually confined to the studio itself. It does not affect or interact with the teaching of other subjects in the curriculum [4]. The adoption of a PBL-like approach in specific courses within traditional programmes is not a difficult issue. The challenge becomes evident only when the goal is to simulate true-to-life design tasks across the course subjects of the whole curriculum.

We argue here that similar problems are present in a CABD post-grad curriculum. Several have been the PBL experiences into CABD teaching [5][6][7][8][9][10]. However, most of them deal with specific teaching modules, are applied within the boundaries of the design studio itself or try to integrate computing into an existing curriculum [11] rather than causing actual changes to its structure.

II. THE NATURE OF DESIGN PROCESS

If the objective is to simulate a true-to-life design task across an entire programme, or at least most of it, then an understanding of design theory, particularly the design process, becomes extremely relevant to the curriculum structuring.

Many have undertaken to describe the design process in the last 40 years. Some of these descriptions have been adopted in the professional world and in the teaching of building design as a standard: brief, preliminary studies, legal project, working drawings. The main problem with such descriptions is that they actually describe the products of each stage in the design process rather than what happens in the process itself [12]. The result is a linear model where returning to an earlier stage is seen as a failure rather than an inherent feature of design process [12].

Some of the design processes features, as described in [13] are generally accepted today. His arguments have been later validated by others, such as [14][15][16][17].

For the sake of our argument in this paper, we would like to stress here the non-monotonic character of the design process: every formulation of the design problem corresponds to the formulation of a solution. Design problems have no definitive formulation, that is, at any time a formulation is made, additional questions can be asked and more information requested. Any design solution is also appraised on a large number of ill-defined and conflicting criteria. As a result the design process has no terminating pointing: it could always lead to an endless sequence of feed back loops [13].

III. THE NATURE OF A TRADITIONAL CURRICULUM

If a design process is inherently non-monotonic, on the other hand a traditional curriculum, with well-defined courses or modules induces the

fragmentation and serialisation of the teaching process. The usual way of teaching in the design studio is often bound to the design process model described earlier. In other words, it is focused on the products of each one of its stages rather than on a recurrent sequence of exploration, analysis and synthesis of building aspects. This results in further emphasis on serialization, prevents the integration of teaching of different subjects into one design process and discourages the students to handle multiple-criteria design reasoning.

IV. THE STORY OF A PBL CABD PROGRAMME

This paper describes an ongoing post-grad teaching experience in which we have sought to overcome these contradictions. The assumption is that a PBL CABD programme can be implemented by introducing recurrence in the

curriculum structure. This assumption stems from the main stream design theory such as [13][14][15]. However, as mentioned earlier, we never ruled out the possibility of a hybrid approach.

This project was developed in several phases, each of them resulting in a new curriculum model developed during the search for a feasible PBL CABD programme. We describe these phases on the following sections.

A. Phase I: a linear model

The first phase was developed and implemented in academic session of 1998/1999 and at the earlier stages of academic session of 2000/2001. Its model was linear and it was in open contradiction with the stated goals. However, it provided the basis for identifying problems and proposing new hypothesis.

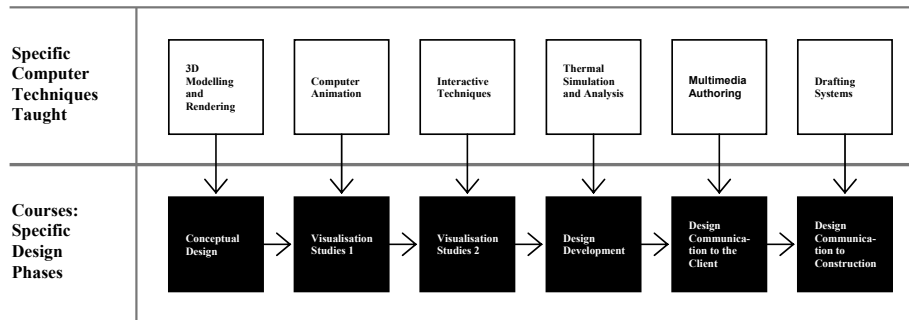


Figure 1. The first curriculum model.

The serial structure of the above model made it difficult to simulate a design process in a way that could at least resemble a real design experience. This had two main causes: first, it did not allow for feed-back loops. Second, the underlying idea of the courses was not clearly defined. Some of the courses were attached to specific stages of the design process and, therefore induced serialization. Others were based on very general activities, such visualization studies, rather than on specific design aspects.

B. Phase II: the introduction of promoted recurrence

The second phase was implemented at the later part of the academic session of 2000/2001 and during the session of 2001/2002. As a consequence of what was observed in the Phase I, a new model, shown in Figure 2, was developed. This model was based on a major PBL experiment where students developed a full length building design project across different teaching modules.

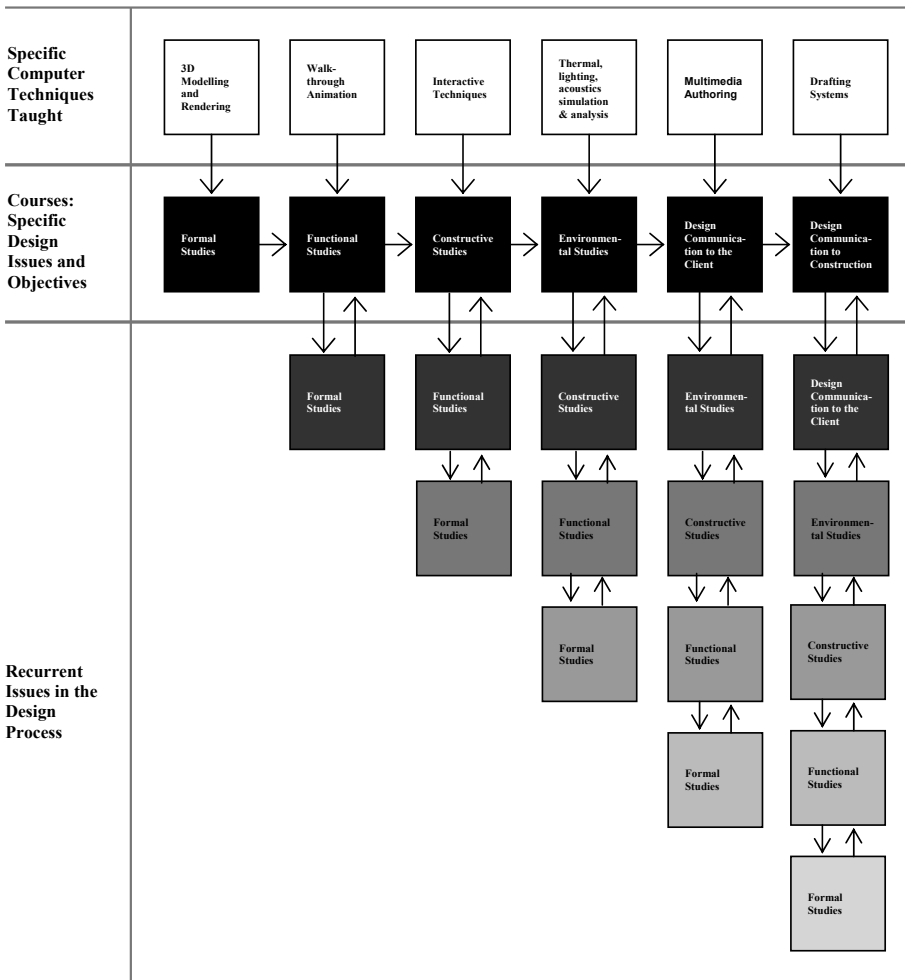


Figure 2. The second curriculum model.

This model was based on the idea of using assessment to encourage recurrence and multiple-criteria design reasoning.

The second row in Figure 2 represents the actual teaching modules that are based on pre-selected design issues. The first row simply highlights the main computer techniques introduced in each module, but the leading element at each module is the pre-selected design issue. Each module was supposed to introduce its specific content and then assess the resulting product against its own criteria and those of previous modules, as shown in rows 3 to 7. This structure was an improvement over the previous model, but mixing assessment criteria of a module with those of previous ones was hard to implement within each module itself. The main reasons were, firstly, the

resistance of some teachers to the idea of sharing his or her criteria with the ones of previous modules. The second reason was the lack of an overall understanding of the proposed approach by part of the academic staff.

C. Phase III: enforced recurrence and a integrated digital studio

The third phase of this project was developed at the later part of the academic session of 2001/2002 and the entire academic sessions of 2003/2004 and 2005/2006. A third curriculum model, show in figures 3 and 4, was developed with specific modules to promote recurrence and multiple-criteria design reasoning.

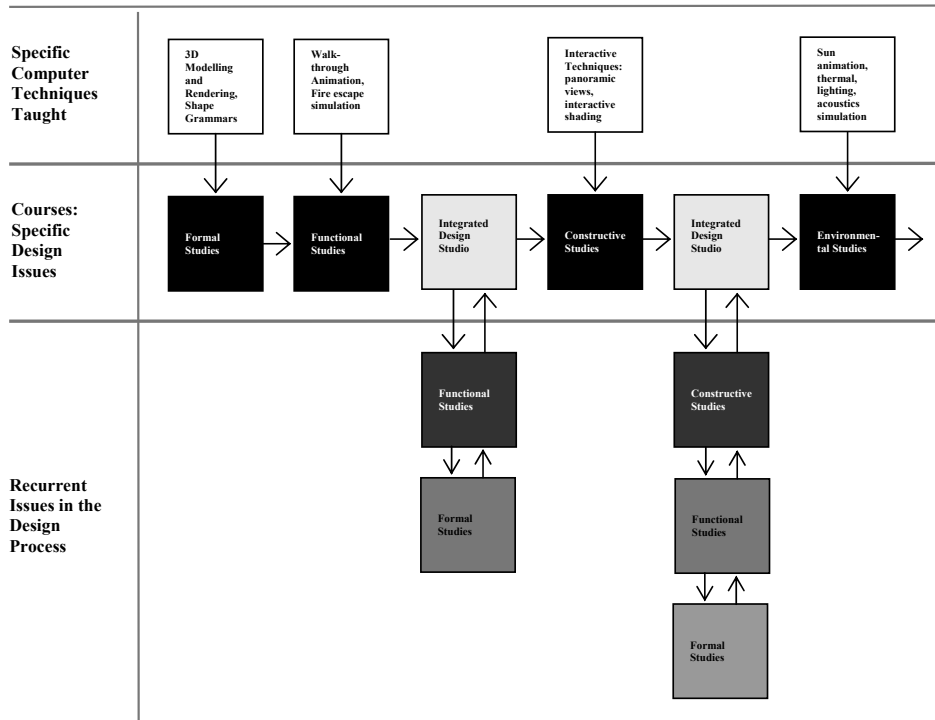


Figure 3. The third curriculum model (first part).

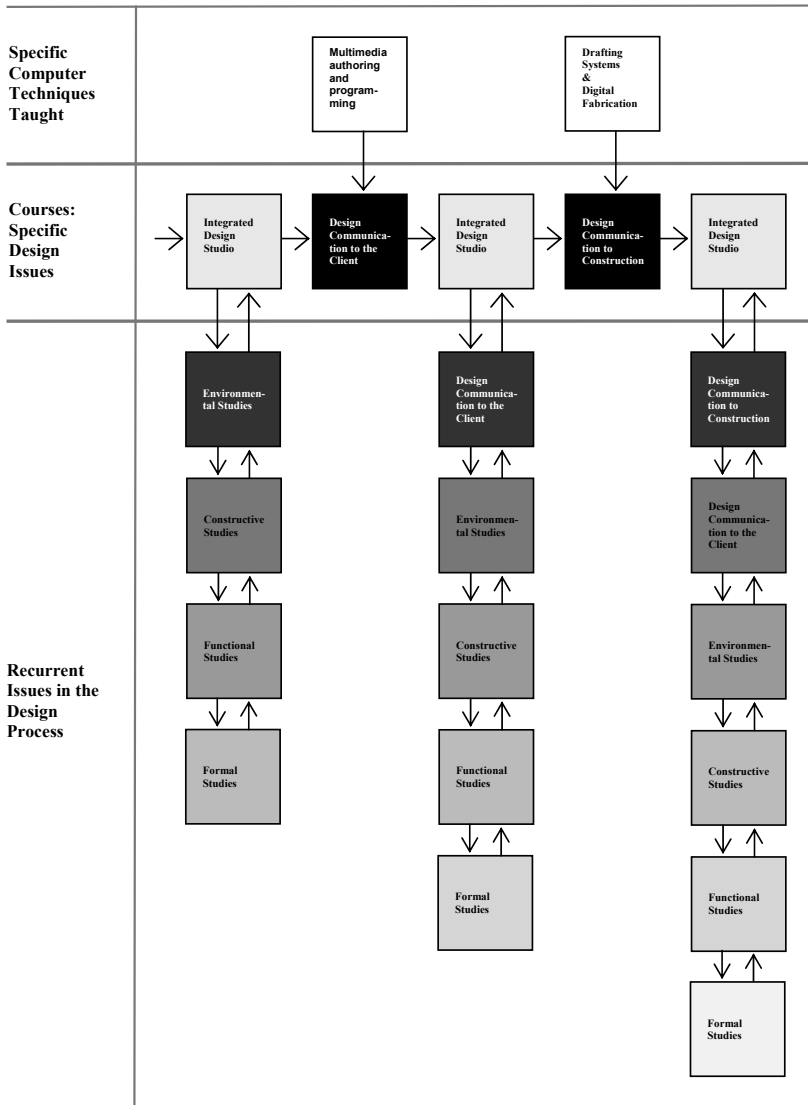


Figure 4. The third curriculum model (second part).

It produced better results than the second model. At was possible to observe that students and teachers were being able to carry out multiple-criteria design reasoning, by seeking to revise previous decisions as a result of assessing their projects against more than one single criterion.

In spite of the shortcomings of the previous phases, in this one was possible to verify its feasibility and to begin to assess some of its benefits. Figure 5 below shows examples of a student's work involving the application of promoted recurrence.

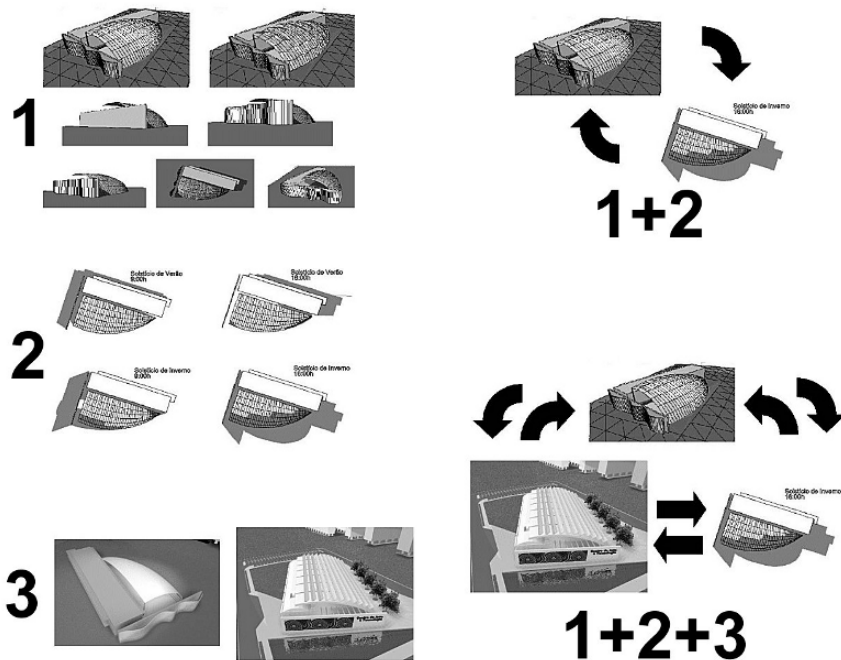


Figure 5. A student's work as examples of enforced recurrence

V. CONCLUSIONS

We believe that we have made a contribution to knowledge by developing a hybrid novel model, yet PBL-oriented, post-grad Design Computing curriculum. We believe that this model may be also useful to architectural education if better PBL-oriented curricula are to be developed in this field. We acknowledge that the approach and strategy need to be more systematically assessed. We have used value-added assessment techniques to help us to achieve a clear understanding of the model's implementation problems and strengths. We will report on that in a near future.

However, the most important contribution was to develop a curriculum model that encourages a change in the way architects view and use computers in building design, a change from design documentation into design exploration, analysis and synthesis. In other words, a design-based approach.

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Towards a Multi-Criterion Web-Based Tool for Evaluation of an E-Learning System

Pavlos Delias, Nikolaos F. Matsatsinis, Agelos Karagounakis
Technical University of Crete
Decision Support Systems Laboratory
University Campus, 73100, Chania, Greece

Abstract- As e-learning systems evolve to a requisite tool for education and as the e-learning platforms' alternatives are enhanced, an evaluation need arise. This need comes not as a valorization process but as a forthright effort to ameliorate e-learning systems. There are many factors, other than learning, impacting behavior, and many factors, other than behavior, impacting performance. In this study¹ we propose a web-based evaluation model which implements a multiple criteria methodology. This technique allows e-learning systems to assess their performance while it exhibits an overall view of their users' behavior. The proposed system was tested through a survey. A brief results' presentation of that survey is also included in the last part of this paper.

Keywords: e-learning, evaluation models, Multiple Criteria Analysis, Decision Support Systems

I. INTRODUCTION

The constant growth of the Web influences over and above education and has a large effect on how courses are designed and implemented. The e-learning perspective has intensely covered the way educational organizations think of teaching. The increasing online access to programs, courses, and course information is exciting. Initial research exploring the potential of online learning has provided some overall insights [1, 2, 3, 4]. Yet, the movement towards online learning is not always assures successful implementation; moreover it is not always confirms the expecting results. E-learning is also one of the areas that attract the most research and development funding. If this investment is to be maximized, it is necessary to generate robust models for the systematic evaluation of e-learning and to produce tools which are flexible in use and consistent in results as well[5].

Additionally, there has been concern among educators that quality assurance procedures for the design and delivery of Internet-based courses have been ignored, as colleges and universities rush to offer an array of distance-delivered programs that will allow them to maintain and grow enrollments [6, 7], therefore they need tools and instruments which will increase their ability to make more analytic and interpretive evaluations of e-learning modules and contents, using a greater range of methodologies.

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In the next section, we try to figure out how researchers commune with evaluation need in e-learning systems while in section three we briefly present a multiple criteria evaluation method. In section four we present the implementation of that method, while conclusions are set out in the last paragraph.

II. EVALUATION OF E-LEARNING SYSTEMS

In every evaluation process there is an interrogative issue that concerns the whole series of actions. This is about the evaluation purpose. Therefore, we wonder what the purpose of evaluation is. Is it about justification and valorization or about improvement? To this question, like many cases, there is no single answer. Evaluation is about both. Anyone who would like to design or implement an e-learning platform should care about its valorization and its amelioration as well. Moreover, that interrogative spirit concerns the evaluation's scope. Should we compare e-learning with traditional learning methods or we should just judge the efficiency of a stand-alone e-learning platform? Is evaluation about a contest among e-learning platforms? These very distinct perspectives lead Hughes et al. [5] to classify e-learning evaluation into the following seven categories: Case studies of specific e-training programs, Comparisons with traditional learning, Tools and instruments for evaluation of e-learning, Return on Investment (ROI) reports, Benchmarking models, Product evaluation and Performance evaluation.

Let us perambulate in bibliography to investigate common features of the proposed evaluation models. Yi-Shun Wang [8] carried into effect a survey intending to end up with an evaluation tool. In his survey, he detected five different instruments [9, 10, 11, 12, 13] that evaluate teaching activities, merely mentioning here Instructor and Course Evaluation System, Student Description of Teaching Questionnaire and Students' Evaluations of Educational Quality Instrument. Moreover he issued a questionnaire in order to obtain some sample data. That questionnaire [8] included a 24-item list that constitutes the total of the satisfaction's factors plus a pair of global satisfaction questions (global satisfaction and success of the e-learning system). While the previous case implements some statistics tools to evaluate e-learning systems, a group-decision approach is followed by Gwo-Jen Hwang et al. [14]. Actually, Gwo-Jen Hwang et al. have developed Educational Web Site Evaluator (EWSE) which is a system that handles methodologies such as multiple criteria decision-making [15], fuzzy logic, Grey system theory [16] and Analytic hierarchy

process (AHP) [17]. A technical approach to evaluate an e-learning platform is presented by the UCF research team [18] who has successfully designed and executed a mail-based survey system for evaluating the university's distributed learning initiative. Building on their work, the authors designed a Web-based survey system featuring three components: data collection, data validation, and data analysis.

According to the above approaches of e-learning systems' evaluation plus according to the standardization that ISO and IEEE [19, 20] have established about software quality, an efficient way to measure these systems' performance is a multiple criteria approach. Each criterion is qualified with its own weight and the total grade of each alternative (in our case the term "alternative" signifies an e-learning system) is a weighted sum of alternative's ratings in each criterion. Furthermore, although the criteria are being decided by experts, the evaluation is procreated by the end-users. The number of those criteria is pretty large (above fifteen) so there is a need to be presented to the users in a homogeneous way hereby there is an additional need for grouping those criteria into definite and unambiguous groups. Nonetheless, in the field of e-learning evaluation systems (as in all multiple criteria problems) there is deficiency in estimating criteria weights, resulting to an assumption but also to a challenge that we try to face in this study.

III. THE PROPOSED METHODOLOGY

A. Main principles and notations

Foremost, we should retain that the evaluation process depends on the users' judgments and that the more satisfied the users are, the higher the system should be evaluated. Considering users' global satisfaction as an additive function, we just have to compute an additive formula to aggregate every dimensional satisfaction. What often happens in quantitative methods and data analysis techniques [21] is a two-level or three-level regression analysis between overall satisfaction and satisfaction originated from criteria and sub-criteria. In this model there are still the ordinary questions about the overall satisfaction and the dimensional satisfaction arrived from each sub-criterion. However, we bridge these questions joining a criteria level. While the questions of the global and the partial satisfactions are being answered by a numerical scale 0-10 (where 10 means absolutely satisfied), criteria's satisfaction is measured by an ordinal scale. This happens because criteria refer to a more abstract topic (such as those described in the next section) and a vobable term would better describe users' preferences, while every sub- criterion corresponds to a very specific and quite measurable characteristic. It should be noted that the method follows the principles of ordinal regression analysis under constraints, using linear programming techniques [22, 23, 24] and may be considered as an extension of the MUSA satisfaction evaluation model [25].

Based on the previous framework, the proposed model infers a set of value functions X_i^* respecting the assumed value hierarchy of user satisfaction. By this way, the model can

handle qualitative (ordinal) as well as quantitative data. The main objective of the model is to achieve the maximum consistency between the overall satisfaction judgments Y , the value functions X_i^* and the sub-criteria satisfaction judgments X_{ij} . It should be emphasized that while Y and X_{ij} are ratio variables measured in a 0-10 scale, X_i is a set of ordinal variables. Unfortunately, due to space limitations we shall not present the model in this paper. The interested reader may refer to [26] for a complete model's presentation and verification.

B. Criteria Selection

Although the proposed methodology could be used including any criteria and sub-criteria ensemble that represent a hierarchy form, in this study we suggest an indicative set of eleven sub-criteria that refer to three main criteria. As mentioned in section II, the evaluation's dimension should spread across the fields of users' satisfaction, teaching activities' effectiveness as well as of the software quality domain. The criteria selection is based on the relative work published in [26]. Of course the criteria set was adjusted to our survey needs, namely to the clients of the system which were all university students.

Therefore, when deciding about the evaluation criteria, we ought to consider that the criteria should scatter the above topics, while their number should remain small. Further properties that the criteria should fulfill mainly refer to their structure and they are proposed by Keeney [12]. For instance, in the proposed methodology, all the questions that users are being asked are satisfaction-oriented in such a way that the satisfaction's conception inheres in every simple question. For example, if a criterion is about "response time" then the corresponded question is "Are you satisfied of the response time of the system?" Conversely, the effectiveness of teaching activities and the quality of the software can not be evaluated this way; hence we should implement a criterion that would be more teaching-aware and another one that would particularly concern the software's quality topic.

Thereupon, three main criteria were decided to altogether evaluate the e-learning systems. First of all, there is an "interface" criterion which awakes users' aestheticism. It mainly concerns the presentation layer of the system and it employs four sub-criteria [13, 22, 25]. In order to delineate the teaching activities' dimension, the "contents" criterion is implemented. Its five sub-criteria venture to depict the ability of the system to achieve its original objective, and that is the learning idea [1, 2, 4, 18, 21, 22, 27]. Finally, a software entity is perpetually judged by its performance. Hereby the "functionality" criterion emerges. We attempt to remain consistent to the software quality ideal while keeping in mind that end-users can not always evaluate all functionality issues (only administrators of the systems could evaluate them all!). So, we surveyed just two sub-criteria about system's functionality [9, 15].

Approaching the "interface" concept, the proposed methodology contemplates on the web design's style. The question that arises in this point is about users' design expectation. This is a question just for the optical effect and not

for the ergonomics aspects of the design. These aspects refer to the “user-friendliness” sub-criterion that surveys the guidance that the system provides the user with. The “Navigation” sub-criterion checks over the user’s ability to navigate through the e-learning system’s working environment. Finally, we examine if the communicative functions of the system really enhance it. Let us define the communicative functions as the chat rooms, the forums, the FAQs, the e-mailing potential etc.

Things are quite more straightforward in the “contents” criterion: “structure of contents” sub-criterion reveals users’ satisfaction about data organization while the up-to-date part of the system is being checked up by a corresponding sub-criterion. Moreover, two separate sub-criteria are used to examine not just only the sufficiency of the contents but also the potential of extra learning-source. Finally, users are asked whether they are satisfied with the format of the contents, that is if data are readable and downloadable.

The third criterion concerns the functionality of the system as a software object. We should keep in mind that e-learning systems are web-based systems therefore we surveyed the following dimensions: the response time that must be kept at a minimum level and the users’ expectations about the reliability of the system. A more analytical description of the selected sub-criteria (along with them that we have rejected) could be found in [26].

IV. IMPLEMENTING THE EVALUATION SYSTEM

The implementation of the methodology we presented at the previous section demands an interface to provide access to users in order to let them evaluate the system and to monitor the results, a logic module to perform the calculations needed and a database to store the information. These demands lead us to three-tier architecture. Users access the system through a web interface where they can submit their assumption on the e-learning platform and they can observe the results of the evaluation process. Middle tier is responsible to solve the linear problem mentioned in section 3, to perform all the necessary calculations and to update the database. Database of course is a distinct tier.

A. System’s output

The results that are published consist of the following:

1. Overall Satisfaction Index : this average index shows, in the range 0-100%, the level of global satisfaction of the users; it may be considered as the basis average performance indicator for the e-learning system and is calculated as the average of the Y answers
2. Criteria value functions : These curves shows the real value (0-100) that users give for each level of the criteria ordinal satisfaction scale; the form of these curves indicates how demanding users are for each criterion
3. Criteria & sub-criteria satisfaction indices: These indices demonstrate the level of partial satisfaction of the users to every criterion and sub-criterion, similarly to the overall satisfaction index

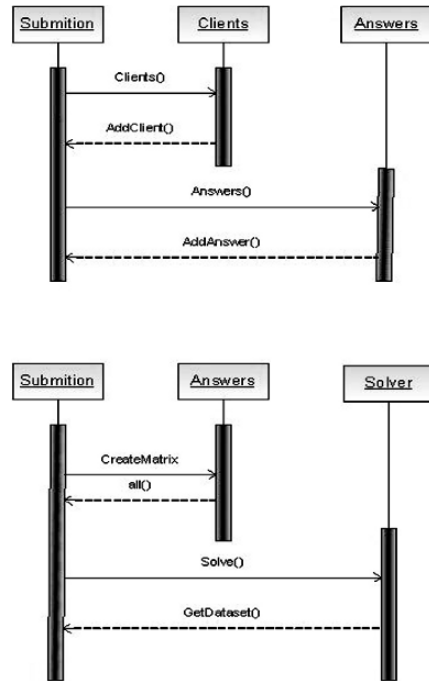


Fig. 1 Sequence UML Diagram.

4. Weights of criteria & sub-criteria: they show the relative importance within a set of criteria.
5. Demanding indices: these indices concern the criteria the sub ones and the overall satisfaction. They are normalized in the interval [-100%, 100%] and they are calculated based on the set of estimated added-value curves; these indices show users’ demanding level (globally and per criterion) and they may be considered as an indicator for the extent of the system’s improvement efforts. An index of “-100%” demonstrates totally non-demanding users while an index of “100%” demonstrates the opposite.
6. Action diagrams: these “performance/importance” diagrams are developed through the combinations of criteria weights and satisfaction indices. They are similar to SWOT analysis and they can represent the strong and the weak points of the business organization, indicating which satisfaction dimensions should be improved.

B. Pilot Testing

The proposed system was tested through a survey. The survey was conducted at the Technical University of Crete during the second semester of 2005. Students were asked to evaluate the e-learning platform that they currently use at the university. A total of 286 valid responses were collected. Although an analytical presentation of the results is out of the scope of this paper, we briefly present them, in order to demonstrate the potentials of the system.

TABLE I
SURVEY RESULTS

	Metric	Satisfaction index	Weight	Demanding index
Interface	Web-design	78.8%	5.65%	-45.8%
	Navigation	85.6%	7.38%	-58.5%
	User-friendliness	95.2%	3.56%	-91.1%
	Communication	55.6%	34.35%	-14.4%
	Criterion 1	94.8%	50.9%	-88.2%
Contents	Structure	79.9%	2.16%	-56.5%
	Up-to-date ness	69.2%	1.5%	-37.7%
	Extra links	57.1%	1.22%	-22.6%
	Sufficiency	84.4%	3.14%	-69.8%
	Format	92.7%	7.67%	-86.1%
	Criterion 2	82.7%	15.7%	-61.9%
Function.	Response Time	85.8%	5.13%	-61%
	Reliability	95.4%	28.17%	-92.9%
	Criterion 3	92.7%	33.3%	-81.8%
	OVERALL INDEX	92.1%	-	-84%

At this point, we shall remind that the satisfaction indices for the sub-criteria and the overall criterion are the average of the students responses altered to a percentage. For the criteria indices, these are calculated as the sum product of the number of responses at every level of the ordinal scale multiplied by the corresponded value of those levels, as it provided by the value functions.

Action diagrams are two axes chart that has on the x-axis the importance of each criterion (or sub-criterion), namely the weights of the criteria; and on the y-axis the performance of the criteria, namely the satisfaction index. Criteria are illustrated relative to global actions and sub-criteria are illustrated relative to criterion-bounded actions. Figure 2 demonstrates such an action map:

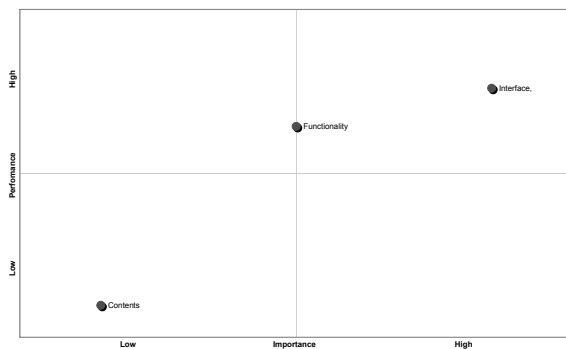


Fig. 2 Action map for the e-learning platform.

Decision makers should action and improve the elements that are located at the lower right quadrant, that is criteria that are important but the system is not performing so well. Action maps also indicate that in case of lack of resources, then decision makers should transfer resources from the elements that are located at the upper left corner, that is criteria where the system is performing well while this is not a priority.

V. CONCLUSIONS

Evaluation is an essential component of program improvement and renewal and long-term success. Furthermore, when the evaluation occurrence concerns educational activities, evaluation results turn to become more sensitive and can be extrapolated to improve the distance education context. Hence, there should be a growing practice of building evaluation modules into an e-learning platform through the use of on-line tools. These tools should assess students' perceptions and preferences. This notion should be examined from the perspective of the pedagogical assumptions underpinning it and the robustness and usefulness of the data generated in this way. The method we presented in this paper uses the analytic – synthetic approach mentioned in section three and implements a web architecture outlined in section four; it tackles these assumptions and provides e-learning decision makers with reliable data. We consider the proposed tool to merge existing research and to join e-learning researchers towards this vision.

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Novel Aspects of the Use of ICT in Mathematics Education

Olga Caprotti
University of Helsinki

Mika Seppälä
University of Helsinki and
Florida State University

Sebastian Xambó
Technical University of Catalonia

Abstract. During spring semester 2006, a synchronous on-line course in basic calculus was offered at the University of Helsinki, and a voluntary remedial synchronous on-line course in geometry was offered at the Technical University of Catalonia. Both courses used the iVocalize conferencing system. Students' feedback was very positive, and it is clear that synchronous on-line delivery of education will emerge as a real option at the university level. How to keep students focused during an on-line class, and how to discuss complicated mathematical problems are the main challenges. Traditional contact instruction cannot be simply transmitted electronically. Just like recorded theater plays are not movies, the content and the way how to interact with students must change for mathematics education to be successful in a virtual setting. Here we offer our views on how instruction will benefit of technology in the near future, and discuss some technical solutions provided by the WebALT eContent Project [5]. Recorded short lectures, automatically graded exercises and examinations have big potential both in traditional contact instruction and in on-line education.

I. CHALLENGES

The main challenges in all education are how to keep students focused in the subject matter, how to motivate them to work independently, and how to fight the high drop out rate. These challenges are accentuated in the on-line setting in which the direct contacts between the students and the instructor are limited. It is easier for the students not to focus when the instructor does not see them. And it is easier for them to drop out because, in the on-line setting, they interact with a computer and not with a person. Moreover, these difficulties are, if anything, more acute in the case of mathematics.

Another challenge in the use of technology in instruction is the fact that it is not easy to write mathematical formulae within a conferencing system in real time. Under such circumstances, the materials need to be pre-prepared trying to anticipate the students' questions. But it is clearly not possible to anticipate every possible question and hence we are faced with the fact that to be able to discuss mathematics on-line freely without prepared materials is today a crucial

requirement. Actually this difficulty regarding expressing mathematical formulae in the virtual setting is probably the main obstacle slowing down the spread of e-education in the sciences.

In spring semester 2006, we taught two undergraduate level university courses in mathematics fully online: a basic calculus course offered at the University of Helsinki, and a remedial geometry course at the Technical University of Catalonia. This paper starts by describing these experiences in synchronous remote lecturing of mathematics. The next section deals with a very important area in which the introduction of ICT has the potential to revolutionize teaching habits, namely administering online assessment and testing by automated software tools. Such learning environments are easily accessed and can be improved by new hardware solutions providing mobile accessibility and friendly interfaces. Older technologies, like Java applets, are revisited in Section V, where we reflect on using virtual laboratories of mathematics with students. Section VI considers ICT in the more traditional setting of teaching in front of a classroom full of students. In the final section we gather the more significant conclusions.

II. SYNCHRONOUS ONLINE COURSES

A. Pilot Courses Aim and Implementation

The aim of the pilot classes was to test the efficacy of teaching a course in mathematics purely online using currently available technology. The lessons were scheduled and held at specific times in a virtual classroom setup using conferencing software [1]. The instructor and the students share the view of a browser window, a chat window, and a whiteboard which allows to publish presentations in PowerPoint and to annotate them. While the instructor lectures using e.g. a slideshow, the students hear the voice, may raise hands for asking questions and the lesson can be recorded for later playback.

Currently we have not used live video feeds with the virtual classroom. In particular the students do not see the lecturer at a blackboard or in front of a microphone. Because of the way the presentation material has been prepared, allowing a slow-pace and incremental presentation, the narrating voice and the shared desktop screen are enough for the

online classroom. The recordings then consist of the slide-show presentation (or whatever has happened in the white-board window) accompanied by the speaker's voice.

B. *Calculus at the University of Helsinki*

The first year calculus course has been offered, at the University of Helsinki, as an asynchronous online course for the first time in fall 2004 as an alternative to a traditional contact lecture course on the same topic. The asynchronous online calculus course lead to good results in the sense that the online students fared better in the examinations than the traditional students and the retention rate among the online students was higher than among the traditional students. Hence the 2004 online calculus was a success. This may, however, be partly due to the fact that particularly motivated students selected the online course instead of the traditional course.

For the first time in spring 2006, the University of Helsinki included in the mathematics curriculum a synchronous online calculus course. Lectures and problem sessions took place online in virtual conference rooms and were recorded so that they remain available to the students. Students may also record lectures and problem sessions themselves.

Initially the course was offered with a cap of 40 students. That had to be lifted after the initial technical lecture of the course had over 70 students. Initial expectations were that 35-40 students would finish the course successfully, but it turned out that only 25 students actually took actively part in the course.

C. *Remedial Geometry at the Technical University of Catalonia*

The syllabus of the five-year Mathematics degree at the "Universitat Politècnica de Catalunya" includes a course in Geometry taught on the first semester (September to December) of the second year. The final exams, essentially based on problem solving, are in January and the success rate is seldom higher than 60%. Those that fail the exam can take an extraordinary exam in July, about three weeks after the second semester final exams are over but six months after the regular Geometry exam. It turns out, however, that the success rate in the extraordinary exam is nevertheless low, as most students return too late to their unfinished business in Geometry.

The experience reported here was a first attempt to help those students, from early February till the July exam, with sessions delivered in a virtual iVocalize lecture room at scheduled times and on agreed topics related to the Geometry course program.

Attendance was voluntary and at no cost for the students. The materials were PowerPoint slides in English, but the teacher voice language for the lessons was Spanish and Catalan. Even if it may be too early to draw water-tight conclusions, it can be safely said that the system fosters truly student centered learning, as they pose more meaningful questions, advance more significant ideas and are able to review the sessions as many times as they need to. It is thus

a technology that deserves being thoroughly researched in view of enhancing learning.

In view of the potential benefits for the students, and also for the teacher as an interesting experimenting scenario, the course will be offered again in spring 2007. The design will be improved in different ways suggested by how the first trial developed. Since the students valued very positively a sample of self-assessment Maple T.A. exercises that was made available to them, the course will be reinforced with a comprehensive set of materials for self-assessment and tuning-up basic skills (cf. Section III).

D. *Evaluations of Online Courses*

An anonymous evaluation was carried out at the University of Helsinki in the end of the synchronous on-line calculus course. Two important points emerged.

(1) Recorded on-line lectures, which were made available to all students on the class' home page, were an important component of the course. Students that missed classes were able to listen to the presentations and discussions easily on-line later. In fact, most students studied listening to the recorded sessions.

(2) The bottom line: all the students responding to the survey told that they would recommend the course to their fellow students.

Since the assessment was conducted anonymously, the responses reflect students' perceptions of the course.

III. AUTOMATIC ASSESSMENT

In the past, students used to collect examination exercises and practice using solved problems and exercise problems collected in books such as the Schaum series. Nowadays, the replacement of these problem collections is represented by online assessment systems, able to generate a practically unlimited number of problems and to automatically check the correctness of the answers. Clearly, homework, quizzes and examinations delivered on-line and graded automatically, say by Maple T.A. [2], turn out to be a very valuable component in mathematics courses that really make a difference in the classroom and in online instruction.

Extensive problem repositories allow students to practice in a completely new way. The Maple T.A. system supports a large number of problem types. The algorithmic problems, or template problems, are especially useful. Such problems are actually short programs which generate a new problem every time the program is invoked. Complete algorithmic problems also generate a step-by-step solution for every individual problem with links to supporting materials. Students may still need to work out the solution of the exercises on paper, however, but when they type the answer in the system, they receive immediate confirmation whether it is correct and in case of a wrong answer, they can ask for a complete solution or for a hint if they wish to retry.

E. *WebALT Multilingual automatic Assessment*

The eContent Project WebALT, Web Advanced Learning Technologies, has developed a way to encode simple

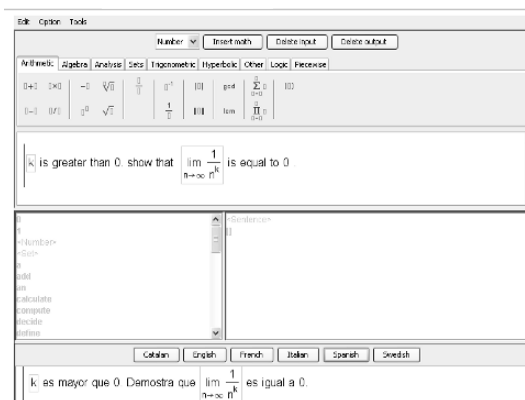


Fig. 1. The WebALT editor for multilingual mathematical text shows on-the-fly the translation of the current sentence and exports the language independent representation in OpenMath or MathML.

mathematical text, like the textual fragments of mathematics problems, in a language independent way. From this encoding it is in principle possible to generate automatic translations of the problems in any language. Currently the best coverage is for English and Spanish with partial coverage for French, Italian, Finnish, Swedish, and Catalan. By a click of the mouse, the user may change the language of the problem from English to Spanish, and then also back as needed. By allowing the student to view the exercises in a preferred language, multilingual tests in mathematics are a way to overcome language barriers in bilingual communities or in communities where there are large minorities speaking a language not supported in school. Moreover, the possibility of using the same exercises in different countries represents a step forward in the process of creating international curricula based on competencies and setting standard assessment procedures for entry levels.

The WebALT editor for multilingual mathematical text is called TextMathEditor and is shown in Fig. 1. This editor can be integrated with Maple T.A. by means of a plugin, available for the popular Firefox browser, to allow authors to edit multilingual question banks and students to choose the preferred language when viewing the exercises. Sample multilingual exercises for Calculus, Geometry and Linear Algebra are available from the project website.

The problem repositories are a most valuable aspect of a learning system and their value is magnified by the technological infrastructure that makes them usable in any class

room. The next section discusses some of the technology infrastructure that is ready today to industrialize and change the traditional view of instruction.

IV. NOVEL HARDWARE SOLUTIONS

The Maple T.A. problems, homework and examinations are delivered over the web. Students using Maple T.A. need only a browser. Practically all students in Finland have a personal computer with fast internet connectivity. Those who do not have computers, can access them in libraries or can even borrow computers from the University Technology Centers just like one checks out books from libraries. Hence instructors may assume that everybody is able to practice using the e-materials offered.

Very soon automatic assessment can be used in every classroom. Students can access systems like Maple T.A. using their hand-held devices like e.g. the new Nokia E61 cellular telephone. This mobile phone has a full keyboard and the conventional browser software that runs on it can connect to the internet either using a WLAN connection, if such is available, or the telephone operator's network.

Browsing the internet using telephone operator's network is, in most cases, prohibitively expensive. Devices which can also use a WLAN connection offer practically free browsing. Such hand-held devices, which can be expected to be very common in the near future, also make the use of automatically graded quizzes and examinations a reality in any class room.

F. The Challenge of the Small Displays

As we have experimented, the 320x240 pixel size of the display of devices like the Nokia E61 is large enough to pose mathematical questions in a very well readable form. Answering such questions requires the user usually to type in a formula. The full keyboard of E61 makes entering a formula easy.

The answer entered in Fig. 2 (left) is rather complicated. It is necessary to be able to view the entered answer as a two dimensional mathematical formula and not only as the linear string that was used to enter it. Viewing the formula given as an answer is supported and we illustrate it with the screenshot in the center.

An attentive reader may have observed that the answer given to the problem in Fig. 2 is wrong! So the student may need to consult the Maple T.A. system to figure out how such a problem can be solved. The third screenshot in Fig.

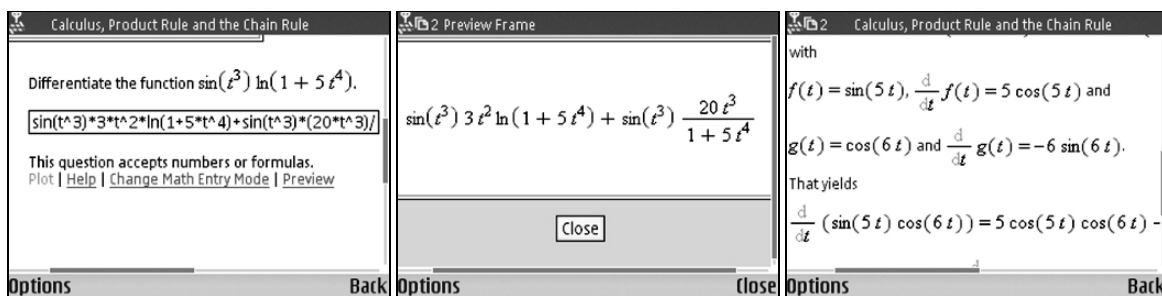


Fig. 2. Screenshots of various steps in the solution of an online MapleTA exercise accessed using a mobile phone. From left to right, the solution is entered, then it is previewed in a pretty-printed fashion that uses 2-dimensional layout of the formula, and finally several lines of a step-by-step explanation are fitted in the display.

2 shows a solution to a problem on the display. Some scrolling is needed to read the solution, but it does not render the solution unreadable. On the contrary, the solutions produced by Maple T.A. to the given problems are very well readable even from its small screen.

It is clear, therefore, as the screenshots in Fig. 2 show, that it is very well possible to use systems like Maple T.A. by latest generation hand-held devices as small and ubiquitous as mobile phones.

G. Mathematics on Touchboards and Tablet PCs

Touchboards, i.e., whiteboards which are touch sensitive computer displays, have the potential to replace ordinary blackboards in contact instruction. In virtual instructions, touchboards offer the instructor the same convenience as the blackboards in a class room. It is as easy to write on a touchboard as on a blackboard. But there is no chalk dust to deal with, nor are there chemicals needed to erase the writing on a touchboard.

Touchboards can do much more than blackboards: touchboards can compute, the writing on a touchboard can be saved in digital format, and the whole lecture can be easily recorded. Furthermore, touchboards can be accessed remotely, and every student can, in principle, write on the same touchboard regardless of their location simply using a tablet PC or a compatible version of the touchboard being used by the instructor.

One of the most convenient features for the mathematics lecturer is the ease by which formulas and mathematical expressions can be input, in a way very similar to using pencil and paper, and converted by the touchboard software into a nicely typeset form. Recent advances in recognition of handwritten formulae also show how, once an expression is recognized as a mathematical formula, it can be automatically processed by computational software that can perform operations on it, e.g. simplification, factorization, integration, and so on.

V. VIRTUAL LABORATORIES

One of the most remarkable and interesting aspects of the ICT use is that it makes possible to recover an experimental facet to the learning of mathematics. This facet becomes smoothly integrated with the conceptual and computational sides, and is driven by computational software hosted in a server. In fact, this sort of experimentation provides in many ways a richer range of possibilities to the learner than classical experimentation. It elicits more novel questions from the experimenter and it decreases by orders of magnitude the time required to find the answers.

One illustration of this is the Wiris virtual lab to support the teaching and learning of error-correcting codes [3], as illustrated in Figs. 3 and 4. Fig. 3 shows the simulation of an experiment for the Hamming [7,4] binary code: a 4-bit information vector u is encoded into the code vector x , then a transmission error is simulated on the code vector, yielding the “received” vector y , and finally the error is corrected

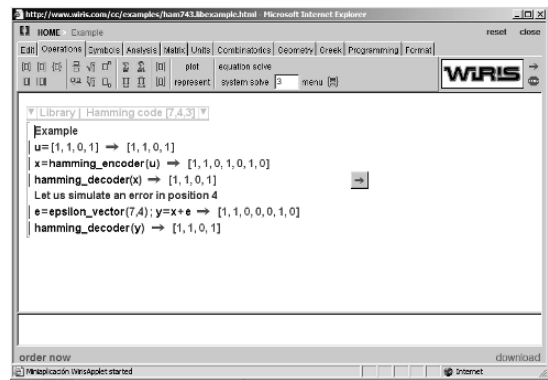


Fig. 3. Screenshot of a cc run (see [3]).

by the decoder. The experimenter can change u and the position of the error, or simulate more than one error.

The connection with the mathematical concepts is best seen by opening the “Library” included in the session and shown in Fig 4. This program is transparent for the student following the Error-Correcting Codes course as soon as the relevant mathematical concepts are understood. Conversely, the basic didactical hypothesis here is that a deeper understanding of the mathematics is achieved by running the relevant experiments in the cc lab, like changing the information vector, or the error pattern, or even the coding of the coder and decoder. In addition, the learner can save the modified session for later reuse, be it for recalling when needed or for further work on the example. Notice the high correlation between the customary mathematical notations and the Wiris code, and the ease with which the Wiris code can be developed by means of function palettes (see Fig. 3).

In the presentation of error-correcting codes [3,4] we tried to balance theory, procedures and experimentation according to the virtuous triangle *MAP* (Mathematics, Algorithms and Programs) as a means of enhancing learning. This is analogous to the design principles of the WebALT learning and teaching materials (see Section VI), which balance theoretical exposition, discussion of applications and problem solving in an integrated environment.

The teaching / learning power of Wiris labs is seen at its best when used in a classroom with a touchboard. In such conditions students can experiment in front of class, explain what they are doing, and have a

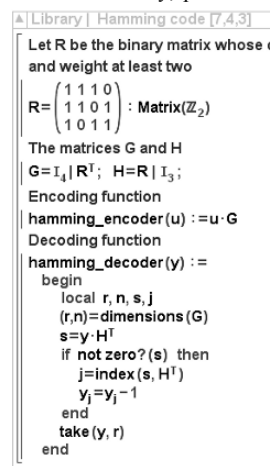


Fig. 4. Wiris functions for coding and decoding the Hamming binary code.

dialog with peers. They can also run the session on the desk or lap equipments available to them. Unfortunately, it is not yet possible to use handheld devices like E61, possibly because of java requirements, but it seems safe to say that this will be overcome in the near future.

VI. IMPROVING CONTACT INSTRUCTION

Most class rooms at universities in the US or in Europe are already equipped or soon will be equipped with video projectors and high quality audio systems. In mathematics instruction these devices are not used very much at all, mainly for the lack of suitable materials.

H. WebALT Courses

The WebALT Courses offer instructors basic mathematics materials broken down into small units, called modules and designed for delivery using computer supported hardware. One module explains only one thing. The presentation of the lecture content of a module takes about 10 minutes to make sure not to exceed the attention span of the student. Along with slide presentations, high quality recordings of the modules will be provided. The instructor acting as a “facilitator” can simply:

1. play a narrated ten minute lecture of a module,
2. discuss that with the students (for typically 5 to 10 minutes afterwards),
3. and finally ask students to solve problems related to the topic of the module.

The recorded modules are not simply recorded lectures, but rather discussions, where several persons discuss the topic under the direction of the main presenter. Questions will be asked, and answers given, at times even in an interactive fashion which requires the active intervention of the listener. These recorded lectures remain at the disposal of the student even after the class. From the experience with the online synchronous courses, the possibility of re-attending the lecture at a later point in time is perceived as very useful.

The problems provided in the module contain both traditional problems to be printed out and solved, and, in many cases, automatically graded problems delivered through the multilingual WebALT System.

VII. CONCLUSIONS

Technology infrastructure to industrialize instruction is ready to be put to use also for seemingly difficult subjects such as those that involve mathematics. Instruction will correspondingly change and the rôle of the teacher will also have to be adapted to the new possibilities. The new teacher will become a facilitator that adopts a technology, either in the classroom or online, and promotes learning using it. Until now, teachers have had the burden to also be technically oriented in order to devise the materials used in lectures. This has slowed down considerably the take up of ICT in fields like mathematics where the technicalities for introducing computer-supported lectures have meant a big work overhead.

Projects like WebALT support the production of high-quality materials for e-learning in mathematics that can be adapted to the students’ level and language and be readily used by the instructors.

The vision is that ICT and computing technologies can in principle be used to address problems originated by the great diversity in the class rooms, not only of background or culture, but also of cognitive style. A single message for all and at the same time is basically missing the point in today’s academic conditions, and only suitably automated instructional systems can come to the rescue. Since education is the main pillar of our society’s future, all efforts in that direction are well spent.

VIII. ACKNOWLEDGEMENTS

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Mediation in Virtual Environments

O. Mäkinen
PhD, University of Vaasa
P.O. Box 700
FI-65101 Vaasa, FINLAND
olli.makinen@uwasa.fi

Abstract – This paper deals with the influence of mediation in different kinds of virtual environments, for example virtual conferences (e-conferences, CISSE), e-learning platforms, distance learning environments and surroundings, and Internet Relay Chat (IRC) and user interfaces. Mediation is a means in which messages, discussion and behavior are becoming more and more conceptual and abstract and have an effect on our social being. Mediation effects on our capability to make independent ethical decisions. The same process is discerned in all the social and commercial practice where it is rationalized by processing techniques or when it's made virtual. Mediation is studied from different perspectives or viewpoints in a phenomenological manner. A mean person could call mediation vitiation or nullification, but that is value judgment. The term quantification as well as modeling and regulation also describe some aspects of mediation. Classical philosophy will be applied in this study, which is an opening in "mediational ethics". An empirical case study (Tritonia Academic Library) dealing with distance learning is also presented in this paper.

Keywords – Mediation, eSocieties, Virtuality, e-learning, Virtual conferences.

I. INTRODUCTION

According to Gilles Deleuze philosophy is necessary especially in situations where new phenomena already exist, and both undefined concepts and words are shuttling in the space. [1] It is philosophy's duty to clarify the unclear situation [2]. This study accepts the challenges proposed by Deleuze and his colleague Félix Guattari. The main task in philosophy is to "invite" and define new concepts [3]-[4]. Mediation as a concept has multitudinous meanings:

In business and jurisdiction the term "mediation" covers any activity in which an impartial third party (often a professional) facilitates an agreement on any matter in the common interest of the parties involved.

In postmodernism, hyperreality is the result of technological mediation, where what passes for reality is a network of images and signs without an external referent. What is represented is representation itself [5]. According to Jean Baudrillard the signs and images take over the reality [6]. Baudrillard says that the real has become an operational effect of symbolic processes, just as images are technologically generated and coded before we actually perceive them. This means that technological mediation has usurped the productive role of the Kantian subject, the locus of an original synthesis of concepts and intuitions, as well as the Marxian worker, the producer of capital through labour, and the Freudian unconscious, the mechanism of repression and desire. From now on signs are exchanged

against each other rather than against the real, so production now means signs producing other signs. The system of symbolic exchange is therefore no longer real but "hyperreal." [7]

In Friedrich Hegel's philosophy mediation (Vermittlung) is a process according to which dialectic process functions: two opposing positions are mediated into a synthesis. Hegel means that all movement occurs in the form of mediation. All the progress we perceive is really a process of mediation. Because mediation occurs on the level of ideas, it also takes place on the level of the universal. Thus, mediation is firmly bound up with the ethical, idealistic and universal sphere.

Danish philosopher Søren Kierkegaard strictly opposed to Hegel's interpretation. Kierkegaard said, for instance, that there is no mediation between different existential stages [5]. Kierkegaard regarded Hegel's mediation (Vermittlung) as a false impression of the nature of reality. Kierkegaard suggested the concept 'repetition' instead of 'mediation' [6]. In the dialectical movement, which is play of ideas and concepts, life itself vanishes and becomes an empty shell. Kierkegaard had many metaphors describing dialectics and idealistic philosophy.

A great deal of Kierkegaard's philosophy came into existence as a protest against the Hegelian influence in Denmark [7]. In "*The Sickness unto Death*" Kierkegaard mocks and describes those huge constructions and systems that consist of nothing but ideas. "The philosopher" creates a perfect system that explains and includes everything, both the world history and everything that exists, a brilliant palace, but he is himself compelled to live outside this creation – in a kennel. [8]

Kierkegaard wrote a whole exemplary book as a parody of mediation. In "*The Seducer's Diary*" [9] the protagonist is practicing the art of seduction so far that he is transformed into a concept. Conceptualisation destroys emotions and all burning sensations in love and other strong feelings.

Immanuel Kant explained in his "*Transcendental Logic*" [10] that we have central concepts that we employ when we are thinking about the world:

According to Kant our most fundamental convictions about the natural world derive from these concepts. The most general principles of natural science are not empirical generalizations from our experiences, but synthetic *a priori* judgments about what we could experience, in which these concepts provide the crucial connectives. (TABLE 1)

TABLE I
THE CENTRAL CONCEPTS OF THOUGHT

Quantity	Quality
Unity	Reality
Plurality	Negation
Totality	Limitation
Axioms of Intuition	Anticipations of Perception
Relation	Modality
Substance	Possibility
Cause	Existence
Community	Necessity
Analogies of Experience	Postulates of Empirical Thought

In this way we produce “mediation”, concepts and standardization all the time. Traditionally this has been the main task of sciences and bureaucracy. It is interesting that the founder of the Phenomenology Edmund Husserl (1859-1938) thought that philosophy had to save the sciences from the natural attitude and careless theorizing [11]. But at the same time we are in the middle of the life flow [12]-[13]. When an individual is interpreting his own life, he is actually moving in the same way as life itself. Husserl calls life-world the ultimate horizon of all human achievement. Individuals as conscious beings always inhabit life-world. It is given in advance and experienced as a unity. It is the general structure that allows objectivity. In Husserl’s later studies an observer or scientist (philosopher) is then situated in the middle of the life flow, bound to historicity and lifeworlds, and somehow he is able to outline the ethical condition of the culture. [14] The final condemnation to mediation came from existentialism or life phenomenology, from such persons as Martin Heidegger, Jean-Paul Sartre and Maurice Merleau-Ponty.

It seems that we have no possibilities to avoid mediation and conceptualization. What effects does this have on our everyday life? It’s becoming more and more abstract all the time. We are producing new language games or are obliged to follow the rules of numerous games others have developed. Life also becomes more complicated and it lacks the personal relations and strong feelings. At the same time we are fleeing, voluntarily or not, all ethical decisions, the language games have taken over this kind of activities.

Ethics has also become different owing to mediation. Via Internet many traditionally location bound problems (pornography, sex, business) have become closer to everyone by means of an Internet connection. The same time we don’t make any important ethical decisions – they have vanished or have been mediated. There is an ethical void in hyperreality.

It is after all Jean Baudrillard who in his essay *The Precession of Simulacra* deals thoroughly with the process of mediation. In images (and why not in concepts) the different phases are the following: a) the reflection of profound reality, b) the masking and denaturing of profound reality, c) the masking of the absence of profound reality and d) the total lack of any relation to reality. [15] The mediation is seen as a natural and ongoing process.

II. MEDIATION IN DISTANCE LEARNING

Distance learning environments are good examples of free activities that are solved in a very standardized and regulated manner when moved into virtual reality. Almost all the indirect speech acts and possibilities to convey through mime are lacking in virtual environments, or they have smaller possibilities to get through. In real classroom situations it is easy to feel – anger, dullness, admiration, acceptance, exhaustion, and to show these feelings. In virtual environments it is on the contrary easy to hide these feelings. In virtuality it is also possible to hide – to be anonymous, which can not be done in ordinary classroom surroundings. For example irony, parody are literary and stylistic effects, but they also have a performative and contextual character.

A good example of mediation in distance learning is the course in information literacy that has been developed in Tritonia Academic Library at University of Vaasa [15]. Information literacy as such is a very standardized phenomenon; the concept of information literacy is new and it has been defined at the same time it has come into existence. The association of College and Research Libraries created a standard for information literacy (Information Literacy Competency Standards for Higher Education) already in 2000 [16].

In Tritonia Academic Library the plans to fulfill Vaasa University’s requirements in the education of information literacy started already 2002, when a member of the staff started to plan a course in that subject. The bureaucrats and the scholars of the university began to understand gradually how useful it would be to introduce an obligatory course in information literacy. This new opening included new methods of learning (self motivated-studies). Earlier the studies in information search and information retrieval had been voluntary. [17]

In the autumn 2004 the course had been completed and it was experimented with a group of students. The Academic Library arranged a pilot course in *Information retrieval and information literacy* for a group of new students in the autumn 2004. This course was a part of Vaasa University’s virtual orientation studies. Tritonia’s part consisted of both traditional lectures, workshops in information retrieval and self-motivated studies with material in the Internet. The Information Literacy Competency Standards for Higher Education were used in the planning of the course. [18]-[19] Very good results in learning were achieved [20].

In 2005 this course became compulsory to all new students. After the evaluation the course was developing into more and more virtual. The main reason for this was the large amount of the students - the resources of Tritonia Academic Library were not sufficient. So in autumn 2004 the lectures held in lecture rooms were “moved to Internet”, the test that had earlier been an essay was performed by means of questionnaire and all the material was available in the Internet. The open, critical discussion and all face-to-face performance were moved into virtual discussion forums.

This progress in the course certainly had many advances. First of all, the governance of the course was now easier. The students registered for the course in the Internet, the quiz counted the results automatically, it was easy for the teachers to see how the course went, how many students had interrupted, which modules they had performed. The teachers could evaluate the degree of difficulty in the test and regulate it and so on. The students were also able to test the standard of their information literacy skills and pass the course by doing the test. The test was based on The Information Literacy Competency Standards for Higher Education and it was developed in cooperation with different Finnish universities. [21]

There were 90 questions in the quiz and the system generated (drew) 30 of them to each student. In the autumn 2006 when 140 students (out of 550) had made the test the teachers noticed that only 40 per cent had passed it. So the teachers lowered the standards/requirements.

With the help of the Moodle-based virtual environment it was easier to govern the course. At present it is impossible to say if the goals in the learning have been achieved – the evaluation is going on. The same concerns the educational standards of the course. In the pilot project the students' information retrieval skills (Boolean logic, truncation, use of keywords etc.) developed notably after two workshops [22]. The course held during the academic year 2006-2007 has not been evaluated yet.

But the course in information literacy had other objectives, too. The librarians and information specialists wanted to come nearer the students, meet all the beginners, make the library a pleasant place, a kind of extension to the living room. The library is worried about how the use of digitalized material changes the way the students use the library.

Because of the virtual course the teachers (librarians) seldom meet the students – and vice versa. All the personal and existential have been eliminated. Discussions are going on virtually in discussion forums, students and tutors don't meet each other face-to-face any more. In the test (the quiz) there are only the true or false answers, no intermediate forms as in modality logic (possible, occasional, random, probable e.g.). Reality isn't as simple as the course, the concepts and mediation let you understand. It may be easy to govern the course but the reality and the contents of the course do not encounter.

III MEDIATION IN INFORMATION RETRIEVAL

As mentioned earlier, in the pilot project the students' information retrieval skills (Boolean logic, truncation, use of keywords etc.) developed notably after two workshops. The information is stored in library databases and it can be characterized as structured, controlled and as a whole was a good example of metalanguage.

When searching information in databases it is very important that in the retrieval both the metalanguage in the database and the needs of the client (searcher) encounter. That is why in information literacy education the learning of formal skills is very important. In Tritonia Academic Library the development of students' information retrieval skills were estimated during

the course of information retrieval [23]. The group consisted of 80 students. The students' information retrieval skills (Boolean logic, truncation, use of keywords etc.) developed notably after two workshops (TABLE 2).

TABLE 2

The task: "How would you truncate the word "immigrants" to ensure the best possible search result?"

	Right	Wrong	No reply
Before the workshops	32	68	0
After the workshops	66	30	4

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.

The same development was seen when the students were asked to make a search for information dealing with immigration/emigration in Finland (TABLE 3).

TABLE 3

The task: "You should make a search dealing with immigration to Finland or emigration from Finland. How would you search?"

	Right	Wrong	No reply
Before the workshops	43	43	14
After the workshops	68	25	7

As seen above, the students' behaviour was developing towards a more abstract direction. They had learned to meet the demands of the database – very practically and usefully. Google, on the contrary, is constantly trying to develop its search engine more and more towards "semantic web". To conclude, these processes, mediation and the progress of semantic utilities, are very contradictory.

IV MEDIATION IN OTHER VIRTUAL ENVIRONMENTS

Many of the other virtual environments try to control and direct the behaviour of the end users. As good examples we have all the different user interfaces to databases, virtual libraries and electronic journals (ScienceDirect, EBSCO, ABI Inform, Voyager Databases). Everything has been standardized in these databases. The documents have been described with constant (standardized) words, so called subjects or keywords (in thesaurus). It is possible to make models or describe different processes in these databases with terms of modal logic (the database itself as construction, very simple; the one who updates the database, processes – rather simple; the designer (or analyst) of the database, processes – relatively simple; the end user, processes – relatively simple). So all the processes are predictable. Here too, the databases don't encounter with the reality, mediation has cast the different actors in the same mould.

People don't necessarily accept the fact that mediation simplifies and conceptualizes reality. Of course it is in people's

interests that there is a limited amount of possibilities, life becomes easier, less complicated. The problem is that they are not able to give expressions to their feelings, describe the complexity and the “biodiversity” of the world in the strict limits of the mediated and standardized virtual environments. They want more, they want to know this: how to express exhaustion, sorrow, anger, jealousy, love, bitterness, hope, joy, all the colours of the world, the nuances – this is not possible in these limits.

Google tries to make the search engine work interactively and to develop semantic web; and as far as the popularity of Google’s search engine is concerned, they have succeeded in their efforts. People want the search engine or user interface to comment or answer even though they have placed the comma in a wrong place or asked a silly question.

V CONCLUSIONS

What are the dangers in all mediation and standardization? The benefits have to do with predictability, simplifying of complicated phenomena (modelling), evaluation and process engineering. It is, however, very difficult to calculate the saves in time and other costs.

We have discussed the “existential lost”. When people have economic surplus they begin to long for experiences that are missing or are reduced in virtual environments. That’s why the producers of those worlds and the actors in different virtual “services” are trying to bring back life to these environments (the development of new languages, smileys, new virtual experiences etc.). So, the development is contradictory – it is based both on rationality and desire for real and original experiences.

When the extremes are missing and mediation takes over, it is always possible that the matters of form take over. It is important to make everything in the only possible way, as in rites or services. The contents become less important. There is a risk that a scholar makes a paper according to the rules and formalities and knows that this is enough to get it accepted, the content is less important.

According to Baudrillard, and Lucas D. Introna, too, an acute risk is that hyperreality is making our ethical sensibility indefinite when we are encountering any serious ethical situations [25]. Where do the ethical contents disappear? I think this is the core question when uncoiling the problems relating to the concept and phenomena of mediation.

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Web-based Interactive Virtual Laboratory System for Digital Circuit Experiment

Ouyang Yang¹, Ye Shiping², Dong Yabo¹, Zhu Miaoliang¹

*1 Computer Science and Technology Department, Zhejiang university,
310027 Hangzhou, China*

{lily, dongyb, zhum}@zju.edu.cn

*2 Collage of Information and Technology, Zhejiang Shuren University,
310015 Hangzhou, China
pye@163.com*

Abstract: With the development of E-learning technology, web-based virtual laboratory has aroused more and more attention of educators. In this paper, we describe the design of a web-based electronic circuit virtual laboratory system for digital circuit. This system provides the user with real expression, convenient operation and powerful simulation capability. Furthermore, we designed segment-simulation mechanism and circuit status persistence mechanism to realize the simulation process in digital circuit. At the moment, ECVlab (Electronic Circuit Virtual Laboratory) has been implemented and successfully applied in an undergraduate course in Zhejiang University and has gained positive evaluation from the undergraduate students.

I. INTRODUCTION

Over the past decade, the development of modern advanced technologies combining multimedia and internet has offered exciting opportunities to the educators. Web-based education technology not only eliminates the time and space restriction of traditional education but also offers new avenue for personalized educational program and collaborative learning activities. Presently, there has been increasing interest in virtual environment which combines distance education, group training and real-time interaction.

Web-based virtual laboratory, a typical application of virtual environment attracts more and more educators and learners for its unique capabilities of successful translation of abstract concepts into visualized events and the interaction of students with them [1].

To meet the requirement of combining E-learning with the experimental education in undergraduate education, we developed a Web-based Interactive Virtual Laboratory System for electronic circuit course (ECVlab). The aim of the ECVlab environment, in general, is to provide an intuitive and interactive web-based virtual laboratory for both analog and digital circuit courses. Details about analog circuit part is discussed in [2], this paper mainly focuses on digital circuit part.

The rest of this paper is organized as follows. In section 2, we list some related Web-based virtual laboratories. The design and structure of the system is specified in section 3. In

section 4, we demonstrate an example of applying our system. Later, an analysis of survey conducted in undergraduate students is presented in section 5. Section 6 concludes our work and points out some directions of future work. Acknowledgements are listed in section 7 and section 8 lists the references.

II. RELATED WORK

Virtual laboratory represents the combination of rapidly-developing internet and multimedia technology. John C.Waller and Natalie Foster [3] designed a virtual GC-MS (Gas Chromatography / Mass Spectrometry) by means of copying presentation of monitor to the screen. Students can operate this virtual instrument via web and the real instrument can be used to take more valuable experiment. Dong Yabo et.al [4] used VRML to realize a virtual chemical laboratory, and provided users with a great sense of realism. Haque, M.E et.al of Texas A&M University applied the virtual reality technology to civil engineering program.

Up until now, more and more research organizations have developed various web-based electronic simulation systems. In an electronic simulation system, the circuit simulation engine plays an important role to provide the system with powerful simulation capabilities. Presently, there are several mature circuit simulation programs such as the Electronics Workbench developed by Interactive Image technologies in Canada, the series software of Pspice in American Microsim Company, and the XSPICE developed by University of California at Berkley and so on. These softwares are widely used in constructing electronic circuit simulation system. Cheng K.W.E. et.al [5] demonstrated a virtual power electronics experiment is programmed in a remotely controlled laboratory setup using equipments such as GPIB, VXI, PLC and so on. It is based on the Labview platform which is developed by America National Instrument, and through this system, user can remotely control the instruments to access important experiment data. And Basher, H.A. et.al [6] introduced a virtual laboratory for electrical circuit course using similar techniques. R.C.Dorf and J.A. Svoboda [7] using Java Applets designed Electronic Teaching Assistant, which enabled students to design virtual

circuit through web browser and to validate experiment results by modifying parameters of the circuit. Ralph Tanner, Johnson A. Asumadu et.al [8] describes a remote wiring and measurement laboratory for electronic circuit, students can access the web-based interface to wire up a variety of circuits and take measurements.

Some powerful and interactive simulation program mentioned above as workbench and Pspice can only be used locally and can not totally support distance learning. However, when focusing on distance education, some systems are lack of interactive capability or powerful simulation support. What's more, most of the electronic simulation system are focused on analog circuit and seldom discuss the digital circuit especially the sequential circuit. The difficulty lies in that these circuit simulation programs cannot be utilized directly to support digital circuit simulation; for their working mechanism is transient simulation while digital circuit needs continuous simulation. Details about this problem will be discussed in section 3.

The major contribution of our work is to design a web-based virtual laboratory system for digital circuit which is totally independent of real experiment environment and can provide users with realistic, interactive and flexible virtual environment. We also put forward a Segment-Simulation Mechanism and Circuit Status Persist mechanism to realize the digital circuit simulation process.

III. THE ELECTRONIC CIRCUIT VLAB (ECVLAB) SYSTEM

A. System Architecture

The ECVlab system uses a Browser/Server system architecture, which is shown in Figure 1.

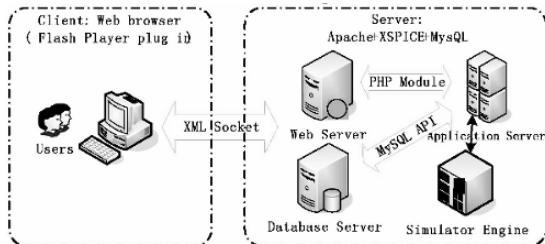


Fig. 1 System Architecture

User interacts with the ECVlab platform through the flash player embedded web browser to perform the experiment activities. When a user starts an experiment, the client side will request for certification from server side. After successful certification, the user logs in to the ECVlab system and at the same time the virtual experiment environment downloads automatically and runs.

The server side is composed of Web server, Database server and Application server. The circuit parameters and control information submitted from client are encapsulated in XML files and transfer to the server side through XML sockets. Similarly, the simulation results worked out by

simulator are also transferred by XML sockets to the client to display.

In a virtual laboratory system, a vivid virtual environment with convenient interaction capabilities is the basic and important characteristic to attract the users' interest and accomplish the necessary education object. The development of the multimedia technology has provided great support to construct a robust virtual environment. In our system, we choose Flash to develop the environment because of its fast load speed, interactivity and animation capability. Details about the circuit virtual environment will be discussed in section 3.3.

On the server side, simulator engine supports all the simulation activities in the whole system and plays a very important role in constructing a powerful and interactive simulation system. In our ECVlab system we use XSPICE circuit simulation program to act as the simulator engine. XSPICE is an extended and enhanced version of the SPICE (Simulation Program for Integrated Circuits Emphasis) analog circuit simulation program originally developed at the University of California at Berkeley. XSPICE provides a rich set of predefined code models in addition to the standard discrete device models available in SPICE and permits a user to simulate analog, digital, and even non-electronic designs from the circuit level through the system level in a single simulator. Figure 2 demonstrates the working mechanism of the XSPICE which is composed of XSPICE Code Model Toolkit and SPICE Simulator core.

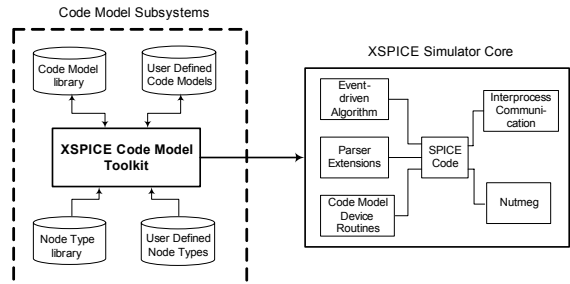


Fig. 2 XSPICE Top-level Diagram

B. Digital Circuit Simulation

1) Problem Description

XSPICE can accomplish transient simulation process. To be more specific, in a certain moment, XSPICE accepts the instantaneous circuit status data and then outputs the results after the simulation process is finished. This simulation mechanism is quite suitable for analogue circuit simulation, in that once the analogue circuit is constructed and powered on, the circuit status will rapidly reach to a stable level, and after that the whole circuit status will not change any more. Therefore, we only need to run the simulator once to get the simulation result. However in digital circuit, the following reasons lead to the fact that we can't use XSPICE directly to realize the simulation process of digital circuit.

- The input signal of the digital circuit is usually a continuous clock pulse which means the simulation process is continuous. At this point, during the simulation process, the circuit status will change constantly. Thus the simulator is required to perform the simulation process every time the circuit status changes.
 - During the experiment process, the user will frequently interact with the system such as press down the buttons and adjust the parameters of the apparatuses. All these activities will reset the circuit status and simulation process will be restarted.
 - Although in XSPICE using transient simulation function, the simulation results of a certain time slice can be work out after the simulation is finished. Whereas the digital circuit experiments usually last for a few seconds or several minutes, even couple of hours, which will results in the long time-cost in calculation process. It will have great influence on the system performance.
- In order to settle the problems mentioned above, we use segment-simulation mechanism. Next section will discuss it in detail.

2) Segment-Simulation Mechanism

In order to achieve the real time effect, we design a segment-simulation algorithm. The brief demonstration of this method is shown in figure 3.

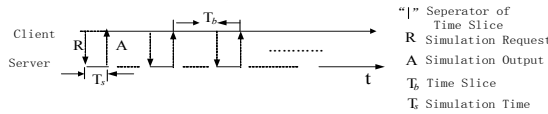


Fig. 3. Work Mechanism of Segment-Simulation Algorithm

We divide the whole time axis into several time slices. As shown in figure 3, at the end of every time slice, a request for simulation will be sent to the simulation program. It will take time T_s for the simulator to calculate the data. After the simulation program finishes the calculation, it transfers the output to the client. Consequently, it will take the client time T_b to display the output data sent from server. After appropriate time the simulator goes on to the next time slice of simulation. All the process will come to an end until the user stops the simulation process. Considering the feasibility of this segment-simulation algorithm, it only works when $T_b \gg T_s$. Fortunately, this condition is fully satisfied in our system.

3) Circuit Status Persistence

In digital circuit, especially in the sequential logic circuit, circuit status is continuous and present circuit status depends on its pre-status. This characteristic results in that the pre-status of the circuit must be stored in order to reset the current simulation process and ensure the simulation result is accurate. It has two significant characteristics in its circuit structure: one is that sequential logic circuit usually includes combinational circuit and storage circuit, and the latter is absolutely necessarily; the other is that the output of the storage circuit must be feed back to the input of the combinational circuit and these two factors together

determine the output. The diagram of the sequential logic circuit is shown in figure 4:

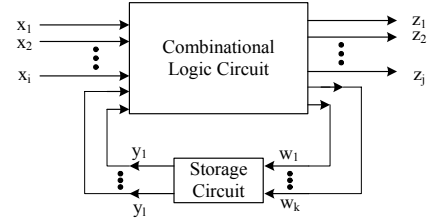


Fig. 1. Diagram of the Sequential Logic Circuit

In this figure, $X(x_1, x_2, \dots, x_i)$ represents the input signals, $Z(z_1, z_2, \dots, z_j)$ represents the output; while $W(w_1, w_2, \dots, w_k)$ represents the input signals of the storage circuit, and $Y(y_1, y_2, \dots, y_i)$ represents the output signals of the storage circuit.

When the whole simulation process is separated into several time slices, the circuit status will consequently be discontinuous. Therefore, in order to keep the circuit conditions continuous, we need to save the conditions at the end of each time slice and reset them as the initial circuit conditions before the simulation of the next time slice. We describe the circuit condition as:

$$S = S_t^i = \begin{bmatrix} \alpha \\ \varphi \end{bmatrix}, \text{ which represents the circuit condition at}$$

time t of the time slice i .

$\alpha = [\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n]^T$ represents the status of the triggers in circuit.

$\varphi = [\varphi_1, \varphi_2, \varphi_3, \dots, \varphi_n]^T$ represents the phase of the input signals

Thus, in time slice i , the relation between the circuit condition on time t and time zero can be defined as:

$$S_t^i = F(S_0^i, t). \quad (1)$$

And the circuit condition at the end point of time slice i is:

$$S_{t_b}^i = F(S_0^i, t_b) \quad (2)$$

Where t_b the length of the time slice and F is represents the circuit status function.

While at next time slice, in the other word, at the beginning of time slice $i+1$, the circuit condition will be set as:

$$S_0^{i+1} = S_{t_b}^i \quad (3)$$

Thus, during the simulation process, the circuit condition will be in a continuous status.

Figure 5 demonstrates the workflow of the simulation process in digital circuit. When the user starts an experiment,

the system will firstly set a reasonable simulation interval, and send the simulation request to the server for getting the simulation result during the appointed interval. The circuit status of the last simulation cycle combined with the parameters in the simulation request is constructed into the input file of the XSPICE to carry out the circuit simulation. After XSPICE has worked out the results, the output data are parsed and sent to the client to display, while the data about the circuit status are kept on server for next simulation cycle. When the output data in one interval for display has been used up, next cycle of simulation process will be triggered.

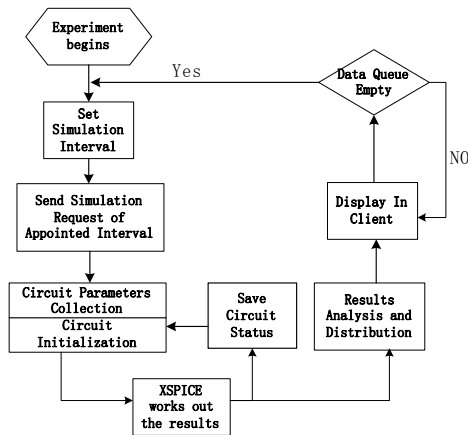


Fig. 2. Digital Circuit Simulation Workflow

C. ECVlab Virtual Environment

The virtual experiment environment is constructed using Flash 7. It supports the object-oriented technology which enables us to develop powerful interactive web animation. The virtual experiment environment can be divided into following modules:

- *Circuit design module*: It provides necessary supports for user to construct circuit. It includes adding or deleting certain components (such as integrated circuits and resistances), modifying the parameters of circuit and lining up between pins.
- *Apparatus module*: it enables the parameter setting of all the apparatus in the circuit and it is responsible for the display of data.
- *Circuit save/load module*: It facilitates the user to save present circuit and load previous saved circuit.
- *Circuit Control Center module*: This module plays the key role in the whole virtual experiment environment. It is responsible for the data transfer between client and simulator on server, data analysis and data distribute.
- *Circuit Examine module*: It is responsible for checking short circuit.

Through the cooperation and communication between all these modules, the virtual experiment environment can accomplish necessary interactive activities of users and give intuitive and real time display of the results. Details about the

relationship between each module are demonstrated in figure 6.

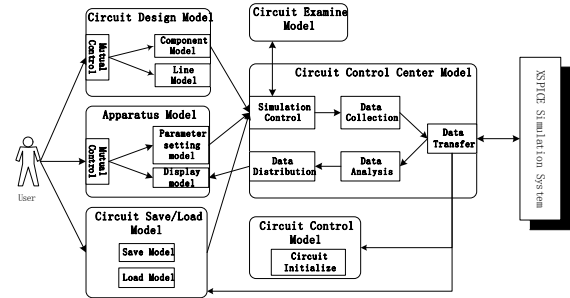


Fig. 3. Virtual Experiment Environment

To make the virtual circuit environment more vivid and close to the real one, the user interface is implemented in a graphical manner and is designed based on the real digital circuit experiment board. The designed virtual laboratory environment is shown in figure 7.

As pointed out by the red dot, on the left hand, it displays the tool bar which contains buttons for different operations. When a user starts to construct a circuit, he can add necessary components with appointed value to the circuit, draw a wire through drag and drop on any pin of components, and change the color at will. What's more, he can save current work or load saved one. On the right hand it lists the guidance of this experiment, and the user can check it anytime during the experiment.

In the center of the virtual circuit board, IC slots are used for plugging different kinds of integrated circuits. A 1Hz pulse and a variant frequency pulse generators are designed for clock input of the circuit, and several seven-segment LEDs are used to display results. We also provide binary data switches.

Once the circuit has been constructed, user can click the power button on the top left corner to start the simulation. When the simulation process is carrying through, the results sent back from the server will be displayed in corresponding devices, such as seven-segment LEDs, oscillograph and so on.

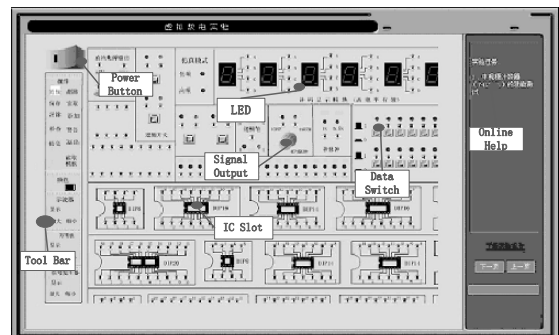


Fig. 4. Interface of ECVlab-Digital

IV. EXAMPLE DEMONSTRATION

We select a digital circuit experiment named “Digital Clock” in the undergraduate courses as an example. In this experiment, students are requested to use two hex counters, 74LS161 and several NAND gates to construct a 60-second digital clock. Figure 8 shows the schematic diagram of the circuit.

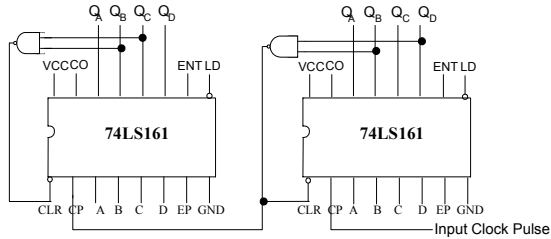


Fig. 5. Schematic Diagram of Digital Clock

Figure 9 is a snapshot of the virtual environment of the experiment. User adds 74LS161 and 74LS00 from the tool bar and line up between them. Later, they connect the input pulse to the circuit and also the output to the related pins of the seven-segment LEDs.

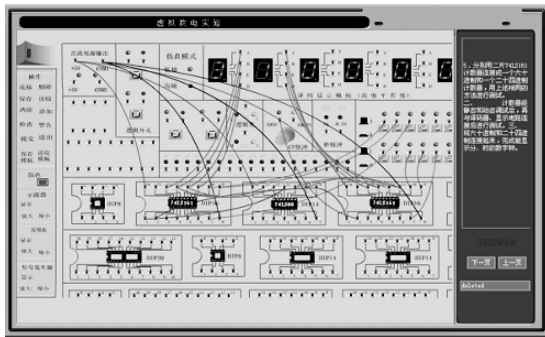


Fig. 6. Snapshot of the Digital Clock Experiment

As shown in figure 9, we can clearly see the number on LED. If the user adjusts the frequency of the input clock pulse, the jumping speed of the digital clock will change correspondingly at the same time.

V. EDUCATION EFFECTIVENESS EVALUATION

Presently, the digital circuit simulation system has been implemented and successfully applied as an assistant E-learning system of the electronic circuit course in Zhejiang University.

In order to evaluate the effects, we conduct a survey among the students who have used the system for a semester. According to the result, around 87% of the students think the ECVlab is helpful to their study, concerning both theory and experiments. Around 45.2% students agree that the ECVlab helps them to comprehend what they have learned from the class. Most of them (67.7%) mention that by using the ECVlab, they can improve their capability of operation and

experiment. What's more, 61.3% students consider it as a good way to improve their interests in digital circuit. Around 59.7% think the ECVlab offers them great opportunity to inspire innovation and exploration. Altogether, up to 95% students rate it positively for its intuitive experiment environment, powerful simulation and convenient interactive capabilities.

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we described the design and implementation of a web-based virtual laboratory system for digital electronic circuit experiment. The successful improvement of this system lies in:

- Provides intuitive and interactive virtual experiment environment
- Put forward segment-simulation and circuit status persistence mechanism to realize the persistent simulation process in digital circuit.

Future developments will focus on improvement of simulation efficiency. For the segment simulation model, we are to design a reasonable and efficient arithmetic to set the simulation interval which can enhance the simulation efficiency and decrease the delay of interaction. Furthermore, the whole work efficiency also depends on the XSPICE simulator itself, and we will make efforts to improve the simulation efficiency of the simulator itself.

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Effective E-Learning Environment Personalization using Web Usage Mining Technology

Ouyang Yang, Zhu Miaoliang

*Computer Science and Technology Department, Zhejiang University
310027 Hangzhou, China
{lily, zhum}@zju.edu.cn*

Abstract: Presently, more and more Web-based technologies are adopted in e-Learning environment to provide users with relatively convenient and efficient access to the resources on the World Wide Web. Personalized support for learners is becoming even more important when the learning recourse volume is increasing with a dramatic speed. This paper represents the idea of using Web usage mining techniques to enhance the personalized capabilities of e-Learning environment. We describe the idea based on three-tier architecture as data collection and preprocessing, pattern discovery and pattern analysis. Brief algorithms in pattern discovery process are presented. We also show the system architecture of how to integrate the Web usage mining process into the e-Learning system.

I. INTRODUCTION

World Wide Web is becoming the most important media for collecting, sharing and distributing information. With the widely adoption of Web-based technologies in e-Learning domain for the purpose of more convenient knowledge acquiring and sharing, substantial innovations have been produced in traditional educational practice. The relationship between tutor and learner has been changed. Learners are not passive absorbers of input knowledge or instructions, but actively construct meaningful knowledge from individual experiences and interests [1].

Research has shown that students learn more effectively when they construct knowledge by selecting and reworking. A flexible approach is needed that is sensitive to each learner's unique needs and context, but also provides focused and structured learning. At this point, personalization has become the most important characteristic that both educators and researchers pay attention to of a robust e-Learning environment. However, students usually lack sufficient awareness and comprehension skills to make effective selection among the large numbers of available learning resources. It could be very helpful if the e-Learning environment could automatically guide the learner's activity or provide recommendation of learning path or related learning resources to the learner based on personal information. Traditionally, instructors will predefine such

kind of learning path or preferred related content, but more intention has been put on discovery navigation patterns of the usage data of those successful learners. The emergence of Web usage mining shed light on the approach to capturing and modeling Web user behavioral patterns and consequently offers good solution to e-Learning personalization.

Web usage mining is the process of applying data mining techniques to the discovery of usage patterns from Web data [2]. In this paper, we introduce the architecture of Web usage mining and adapt it into the e-Learning environment to show how to utilize the ideas to construct a better customized e-Learning system. We also present the algorithms for pattern discovery. What's more, we design the system architecture which adjusts the Web usage mining mechanism in the whole system.

The rest of the paper is organized as follows. In section 2, we introduce three-tier architecture of Web usage mining and put forward brief algorithms in the pattern discovery process. The system architecture is designed and discussed respectively in section 3. In section 4 we describe related works. Section 5 states the conclusions and future works.

II. USING WEB USAGE MINING IN E-LEARNING ENVIRONMENT

A. E-Learning objects

Presently, Web-based learning environment are being very popular. All kinds of e-Learning tools are designed and developed to greatly satisfy various e-learning requirements and support collaborative learning activities such as Web-based multimedia curriculum, on-line synchronous conference systems, white boards, and web-based simulation systems and so on. Those tools not only eliminate the time and space limitation of traditional indoor teaching-learning model, but also provide multiple learning patterns which make the learning process more attractive, efficient and convenient.

However, dew to the distribute and wide-spread nature of both learning resources and the learners in the Web-based learning environment, on the instructor and educator side, it is difficult for them to thoroughly track and evaluate the learners activity and furthermore, assess the effectiveness of

the learning process and the structure of the learning content; on the learners side, information on the web is often not effectively organized and learners have to spend considerable time in unproductive interactions and may not properly integrate information to address their immediate learning need. Although learners prefer to search and select knowledge by themselves rather than directly follow the instructions, they still need some guidance to make efficient and favorable selection. What's more it could be very much helpful if the learning environment could recommend links of correlative learning content which is worked out based on former learners' activity and experience. Luckily, Web usage mining technology such as clustering, association rule discovery and so on provides good solution to satisfy these requirements.

B. Web Usage Mining

Web usage mining provides an approach to the collection and preprocessing of the usage data and constructs models representing the behavior and the interests of users. It consists of three consecutive phases, namely preprocessing, pattern discovery and pattern analysis. We adapt this three-tier architecture in our e-Learning environment.

1) Data collection and preprocessing

To collect enough usage data and create a suitable target data set for pattern discovery is the starting and key point for successful mining process. As any other Web applications, the usage data of e-Learning environment are mainly retrieved from the log files from the server side and the registered user information from the client side.

Server side data are collected at the Web servers which consist primarily of various types of logs generated when the visitors access the Web pages. A Web Server log file customarily includes the information as the IP address of the request; the hostname and the username who makes the request; the time stamp of the request; the method of the request; the file name that is requested and the file size; the URL of the referring pages; the cookies (if applicable)., Web usage mining tools generally use the Web server log files as the main data source for discovering usage patterns [3].

The raw data collected from the log files are usually diverse and voluminous. They need to be processed into more integrated and consistent data set to be used for pattern discovery. Firstly, irrelevant and redundant information are cleaned from the dataset such as the received HTTP error response, entries that refer to image, video, CGI scripts and so on. Consequently, unique users and sessions are identified from the log entries. In web log mining to identify individual users is essential to the personalized capability yet is the major difficult task. Fortunately, in e-Learning environment, this task is greatly simplified since learners are registered users and have to login to the system to start their learning process and logout when they finish. Similarly, to identify user session can be simplified in the e-Learning environment.

Client side data are mainly collected when users register to

the system. The information includes name, age, major, and so on which reveals the personal interests and close individual information in great detail.

To make our work more specific and easy to describe, we make the following definitions:

- **Learning Activity (LA):** A series of the learner's clicks on the e-Learning site;
- **Learning Session (LS):** A sequence of Learning Activities happened during the process from the learner "log in" and "log out" the e-Learning environment.
- **Learning Content (LC):** The smallest unit of learning resources that the learner learns during a **LS**.

2) Pattern Discovery

Pattern discovery uses machine learning and statistical methods to extract usage patterns from the preprocessed Web data [3]. Four main approaches in data mining literature are utilized in Web usage mining as clustering, classification, association discovery and sequential pattern discovery. Most of these algorithms can be adapted in E-learning because of their domain-independence. We will discuss what algorithms can be used and how can they be applied in E-learning environment in the following subsections.

a) Clustering

Clustering aims at dividing data into groups with the members are very similar to each other. Presently, Clustering has been used for grouping users with common browsing behavior, as well as grouping Web pages with similar content [2]. In our case, we can use clustering to group the learners with similar learning behavior (online learning resources access). A clustering algorithm named BIRCH (Balanced Iterative Reducing and Clustering) [4] is widely used because of its hierarchical and incremental features. Details about how to adapt it to cluster web users based on the users' access pattern is introduced in [5]. We will discuss it in detail in other work due to its complication.

b) Association rule discovery

The discovery of association rules usually aims at the discovery of associations between Web pages based on their co-occurrence in user sessions and the navigational patterns of users [6]. In an e-Learning system, the association rules indicate the inner relationship of the various learning resources related with personal interests and behavior patterns. The automatically discovered association rules are essential to improve the system's performance. On the system designers' side, the rules indicate the inner knowledge structure among different learning resources. By analyzing and implementing the mined relation, it could be very helpful to customize the page layouts as well as web site structure. On the learners' side, if the system provides recommend hyperlinks of correlated learning resources based on the personal information of the learners, the learning process will become more efficient and more inspiring.

An association is represented by an association rule as $X \Rightarrow Y$ which indicates the dependence relation between two sets of items, X and Y . The association rule is measured with two features named **support** and **confidence**. Support is the frequency with which the corresponding itemset ($X \cup Y$) appears in the database. While confidence is the conditional predictability of Y , given X , calculated as equation (1):

$$\text{frequency of } (X \cup Y) / \text{frequency of } X \quad (1)$$

We adopt the Apriori algorithm which is put forward by Agrawal and Srikant[7] to discover the association rules of the learning resources which is shown in List 1. The basic idea is to find out all the sets of **LC** that co-occur together within a *Learning Session* with the support larger than the minimum support. We define *k-candidate* as a set of k **LCs**; F_k as set of *k-candidates* with minimum support; P_k as all *k-LC* sets that F_{k-1} is the subset of P_k .

List 1

1. $F_1 = \{1\text{-candidate with minimum support}\}$;
2. **FOR** ($k = 2; F_{k-1} \neq \phi; k++$) **DO**
3. **BEGIN**
4. $P_k =$ all *k-LC* sets of which F_{k-1} is the subset.
5. **FOREACH** *LC* sets p in database **DO**
6. Increment the count of all candidates in P_k that are contained in p .
7. $F_k =$ Candidates in P_k with minimum support.
8. **END**
9. Answer = $\bigcup_k F_k$;

c) Sequential Pattern Discovery

Compared with association rules, sequential pattern contains much more information of the user usage pattern. The aim of sequential pattern discovery is to identify frequently occurring sequence of events. This approach is particularly useful for the identification of navigational patterns in Web usage data [3]. The most important application of sequential pattern discovery in e-Learning environment is to discover the learning path. Learning path is defined as a sequence of links of semantically related **Learning Contents** that a learner can follow so as to grasp a particular learning topic. Traditionally, the learning path is predefined by instructors and designed into the system, what the learners need to do is just follow the path to finish the learning task. However, if more choices for what to be concerned in next step are provided, students will have more flexibility to construct the knowledge structure of their own.

The algorithm we use in learning path mining is mentioned in [8] which is based on the Apriori algorithm. The mining

process is divided into three phases as sort phase, frequent **LC** sets discovery phase, optimization phase and learning path discovery phase.

- **Sort Phase**: the database is sorted with the user-id as the major key and the Learning Session time as the minor key. After this step, the original database is converted into a user sequence database which could greatly facilitate the process of learning path discovery.
- **Frequent LC Sets Phase**: the algorithm mentioned in the former subsection is utilized to find the *frequent LC sets* with minimum support.
- **Optimization Phase**: In order to make the learning path discovery more efficiently, we transform the sorted database based on the frequent LC sets found in the former phase. In the sorted database, in a Learning Session, if it does not contain any frequent LC sets, it is not considered in the following process. What's more, in a user sequence of LCs, if it does not contain any frequent LC sets, the sequence is dropped from the database.
- **Learning Path Discovery Phase**: use the frequent **LC** sets and the optimized database to find out the frequent **LC** sequence. We define *k-sequence* as a sequence of k **LCs**; F_k as set of *k-sequence* with minimum support; C_k as all candidate *k-sequence* sets that generated from F_{k-1} . It is shown in list2.

List2

1. $F_1 = \{1\text{-sequence with minimum support}\}$;
2. **FOR** ($k = 2; F_{k-1} \neq \phi; k++$) **DO**
3. **BEGIN**
4. $C_k = \{\text{set that join } F_{k-1} \text{ with } F_{k-1}\}$;
5. $C_k = \{\text{delete all sequences } c \text{ in } C_k \text{ if any (k-1)-subsequence of } c \text{ is not in } F_{k-1}\}$;
6. **FOREACH** user-sequence c in the transformed database **DO**
7. Increment the count of all candidates in C_k that are contained in c .
8. $F_k =$ Candidates in C_k with minimum support.
9. **END**
10. Answer = Maximal Sequences in $\bigcup_k F_k$;

3) Pattern Analysis

The motivation of pattern analysis is to filter out uninteresting rules of patterns from the result found in the pattern discovery phase. The related rules and patterns are analyzed and interpreted to the users in an easily understandable and operational way. The exact analysis methodology is usually accomplished by the applications, and the designers can define how to select out desired patterns or rules and how

to demonstrate to the users. In our case, we design to recommend selective links to current learners based on the pattern discovery result. Details are discussed in section 3.

III. SYSTEM ARCHITECTURE

We have developed the architecture for the e-Learning environment which adopts the Web usage mining technology. It is shown in Figure 1.

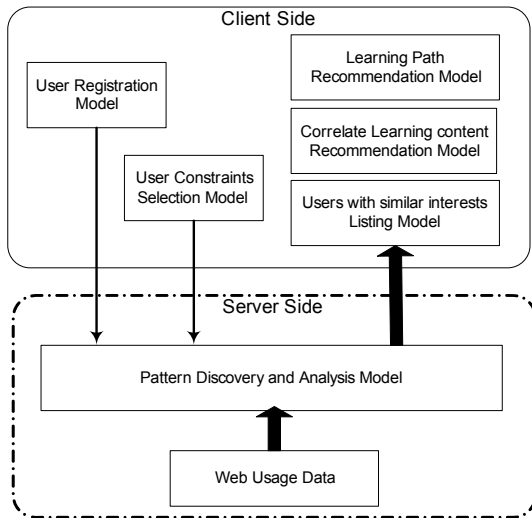


Figure 1 System Architecture

As shown in Figure 1, we have a pattern discovery and analysis model on the server side which plays as the key model in the whole system. It takes three kinds of resources as input as follows:

- Web usage data from the Web Server Log Files
- User registration information
- User-defined constraints

Obviously, the Web usage data is the main source of input. Besides it, we consider the user registration information and user-defined constraints as the compliment sources which are supposed to offer more detailed and self-related individual information. User registration information is the basic information about the user such as name, age and major and so on. For example, we define the field of “Educational Level” to represent the level of the learners such as undergraduate, master and PHD which indicates the learner’s present knowledge level and the potential capability to learn a new content; “Major” to represent the knowledge region that user is relatively good at. Those fields are also used as the constraints for the mining process which the users can define by themselves. For an example, a user majors in mathematics and he wants to learn about “C++ Programming Language”. Considering he knows little about programming language, he should start from the easy content of lower level. Thus he can define the constraints as major of “Computer Science” and

educational level as “undergraduate”. The same kind of information can act as constraints during the mining process. What we need to do is pushing some constraints when selecting candidates from the database according to the requirement. As a result, the users can choose the related content which is close to their educational background or their personal interests; it can improve the customization capability of the learning systems and provide more flexibility to the users.

The result of pattern discovery process is analyzed and sent to the client. There are three main models which use the rules and patterns discovered to provide services to the user on the client side:

- *Learning Path Recommendation Model*: This model uses the result of the sequential pattern discovery process. Several sequences of learning recourse known as the learning paths extracted from user access history are listed, so that users can use them as the references when they are searching for what to be learned next step.
- *Correlate Content Recommendation Model*: This model uses the result of the association rule discovery process. The correlate learning resources that are frequently accessed together with the learning content user learns presently are listed. It expands the user’s eyesight and offers multiply choices for the learners to better grasp a learning topic.
- *Users with Similar Interests Listing Model*: This model uses the result of the clustering process. Users with similar interests or similar navigation behavior are recommended to the current user. With this mechanism, the user is encouraged to search for the potential group mate or the one to discuss with which greatly improve the cooperation possibility of the learning system.

IV. RELATED WORK

The idea of exploiting usage data to customize the web for individuals was suggested by researchers as early as 1995 [9] [10]. Recent years have seen more effort and exiting progress on using Web usage mining technology to make web sites more adaptive and personalized. Azreen Azman and Ladh Ounis [11] presented an alternative technique for discovering aggregate usage profiles from Web logs which is based on clustering of information need. Yue-Shi Lee et al.[12] proposed an integrating path traversal patterns and association rules model for web usage mining in the electronic commerce environment which can correctly capture the user’s traversing and purchasing behaviors. Zhou. B and Hui. S.C [13] developed an intelligent Web recommender system which used sequential access pattern mining and put forward an efficient sequential pattern mining algorithm to identify the access patterns.

Presently, with the increasing need for adaptive E-learning systems, there is a trend of utilizing the Web usage mining techniques in E-learning environment. Song Ho Ha et al.[1] described the possibilities of application of Web mining techniques to distance education. Osmer R.Zaiane and Jun

Luo [14] designed a system which used the Web usage mining techniques to help the educators to better control and evaluate web-based learning systems. In their later work [15], they proposed an approach to build a recommender system of e-learning system which could assist the learners choose pertinent learning activities to improve the learning performance. Ling Guo [16] et al. also utilized the Web Usage Mining to evaluate the users' access patterns and to assist online e-learning assessment.

V. CONCLUSIONS AND FUTURE WORK

This paper discusses how the Web usage mining techniques can be used to construct a personalized e-Learning environment. The work mechanism is described based on the three-tier architecture of Web usage mining as data collection and preprocessing, pattern discovery and pattern analysis. Furthermore, simple algorithms for pattern discovery process are discussed.

In this paper, the system architecture which combines the pattern discovery and analysis mechanism of the Web usage mining is introduced. Example models are designed which use the pattern discovery and analysis results to provide the users useful recommendation and make the learning process to be more attractive and adaptive. It allows learners to focus their cognitive effort on information they need to know in order to do what they want to do.

Future works will focus on the algorithm optimization and system implementation. More useful tools based on Web usage mining techniques are to be developed in the e-Learning environment.

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Tutor: A web-based educational platform for university studies

Roberto F. Arroyo¹, Miguel J. Hornos¹ and Pilar Fernández Sánchez²
{robfram,mhornos,pilarfs}@ugr.es

University of Granada

¹ Dept. de Lenguajes y Sistemas Informáticos. E.T.S. de Ingenierías Informática y de Telecomunicación,
C/ Periodista Daniel Saucedo Aranda, s/n, 18071 Granada, Spain

² Dept. de Métodos Cuantitativos para la Economía y la Empresa, Facultad de Ciencias Económicas y Empresariales,
Campus Universitario de Cartuja, 18071 Granada, Spain

Abstract. This paper presents Tutor, a web-based educational support system for university-related teaching, learning and academic data management. It explains the most relevant aspects of its design (e.g. underlying role-based model and architecture) and the main operations that each type of user can perform in the system. It also analyzes the answers given to the questionnaire completed by the students in order to discover what they thought of the system.

I. INTRODUCTION

Teaching staff has recognized the need for effective tools to manage information resources for their students' progress and for their subjects. In recent years, in the context of the European Space of Higher Education [1][2], the development of electronic communication channels has allowed higher levels of cooperation within the educational community. Nowadays, computers are everywhere, and university students are able to communicate each other no matter where they are. ICT (Information and Communication Technologies) like World Wide Web [3] became one of the main mechanisms for remote interaction, and has reshaped both society and universities all over the world. Universities must capitalize on the web for teaching and learning, and the increasing use of web-based systems is a progressive manner to be on the way.

According to these needs, the University of Granada has created several plans of educational quality [4][5]. Within them, we are developing a teaching innovation project, which tries to build a web-based platform called Tutor (<http://tutor.ugr.es>). This system is made up of several electronic tools, based on innovative ideas and effective techniques [6]. The possibility of incorporate ready-made components is also considered. We have used this web-based toolkit to create a teaching aided system to support teaching staff and students.

The toolbox must provide a pedagogical approach to the issue design for increasing the usefulness and fulfilling the proposed objectives. The main purpose of this paper is to present the work carried out in developing this toolkit-based teaching aided system that allows achieving three main aims:

- To provide additional information focused on academic contents, like subject syllabus, files, glossaries of terms, learning activities, etc.
- To establish new communication and interaction channels between the different academic members.

- A better management of all registered users, providing a secure authentication method to preserve identity and privacy of users.

We believe that this produces an alteration in the pedagogical behavior of the academic community, and as developers willing to have a successful deployment of this toolkit, we must evaluate the acceptance or rejection it produces among them.

This paper is organized into five sections. Section II outlines the conceptual design involving modeling and architecture decisions. Section III explains the main components of our toolkit, and the related operations that each kind of user can do in the system. Section IV presents the results of a statistical study conducted among students about their use and level of acceptance or rejection. And Section V expounds our conclusions and future works.

II. MODELING AND ARCHITECTURE

A. Modeling

The platform designed follows a role driven approach, using a role-based model. Firstly, the system roles are distinguished and the different parts that made up the whole system are developed. Next, we establish relations between roles and parts using their operations, implemented on a later developing stage. For operation modeling we used a user driven design, which provides a higher abstraction level for system task description and separates the concepts of users and roles.

Using a role driven approach lets different functionality according to the role played, which is reflected on the user interface. The system distinguishes between four user profiles: administrator, teacher, student and unauthenticated user. When users log in to the system, it automatically recognizes the roles they play. Once access has been granted, the system displays a menu with the sections and actions allowed in accordance to the role the user is playing.

Fig. 1 shows the user profiles and roles that Tutor recognizes. Our system has been designed in such a way that permits a user to play several roles concurrently. For example, a teacher can be in charge of a theoretical group and two laboratory groups of a subject, and be the coordinator of that subject too; these three roles could be played by him/her at the same time.

B. Architecture

The system is based on a client/server [7] approach with dynamic content generation. A relational database is used for data storage, and a CGI [8] collection of PHP [9] scripts for implementing operations and generating the HTML interface. This part is server side, both for storing and executing. As client, the user can use any web browser, being able to access the platform from any place with an Internet connection and a XHTML/CSS [10] compatible browser.

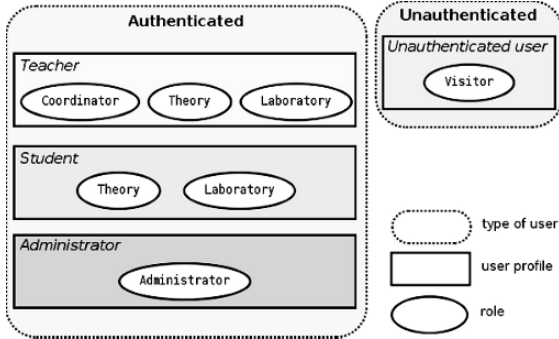


Fig. 1. Structure of user profiles and roles.

III. SYSTEM OPERATIONS

As we commented before, the system presents a set of operations to select depending on the role the user is playing at each moment. However, there are some public navigation areas where general information about subjects, teachers or centers is shown. In these common areas the role is not important, and an unauthenticated user will receive the same information than a logged student or even the system administrator. Nevertheless, there is a restricted area too (called *Restricted*) where only logged users can access. This area is not available for unauthenticated users, and it contains different options for each role associated to the three authenticated user profiles (administrator, teacher and student) the system defines.

A group awareness mechanism is present all the time, showing the number of users playing each of the four roles on the system, the three authenticated and the one unauthenticated.

Now, we will shortly comment the most relevant aspects of the available operations for each kind of user.

A. Unauthenticated user

Every user visiting the platform without using a login and a password gets the unauthenticated role. This role lets him/her to visit the public areas, hiding any restricted operation. To access any restricted operation, users must fill an authentication form to identify themselves into the system, and get the corresponding role inside the three available profiles for authorized users. The only operation permitted for this role is therefore to browse public information.

Users can consult information relating to the platform project in the *Introduction* section, where a short abstract about project history and objectives is shown. An area called *Staff*

shows concise information about the platform developers (project members) and collaborators (teachers who use it). This information includes a link leading to their (electronic) card, which extends their personal information. The visitor is therefore able to consult tutorial schedules, offices and phone numbers among other information. Moreover, the section *Subjects* contains detailed academic information about all the subjects managed by the platform.

The section *Links* provides links leading to interesting web pages relating to subject contents. These links are chosen by teachers and project members, and classified by categories. This section is publicly available for everybody interested in. In addition, a *Notice Board* section containing the most recent notices (written by teachers or the system administrator) can be consulted. However, only those messages sent as public notices could be read.

The last public area (*Suggestions*) provides a mechanism to send suggestions about platform or any subject managed by it to the most appropriate person, whose name is selectionable from a combo box containing different items that depend on to options previously chosen. This section was created to provide to users a mechanism for notify bugs, solve doubts and improve system features, according to the suggestions received.

Finally, we cannot forget that any authenticated profile can navigate for these sections, but we will omit references to them while describing next roles. Once authenticated the user, the system will show the corresponding restricted area in accordance with the roles he/she is playing.

B. Teacher

The teachers are responsible for inputting information for their groups. They must provide the complementary didactic material their student may need into the download area. They must propose homework for their students, using the corresponding operation.

They must mark the exams and tests done by their student, and introduce their grades into the system through the appropriate option.

Those teachers who were coordinators of some subjects managed by Tutor in the previous academic year can activate the subject at the beginning of the new one. This operation lets modify the teacher staff to the subject in order to introduce into the system changes in the teaching organization of the present academic year with respect to the previous one.

When teachers insert a theoretical group they must provide the list of students enrolled on it. This process adds these students as new platform users, if they were not registered in the system previously, and therefore provides an automatic method for registering new students without contacting with system administrator. Additionally, teachers can insert or delete individual students. When they create a laboratory group, they must specify a period (initial and final date) in which students can register in it, and an optional list of theoretical groups whose students are only allowed to register in that laboratory group. The class schedule could be specified at that time, for theoretical or laboratory classes. The tool which allows to track the attendance to practical classes enjoys a great

success among teachers, since it makes easier this task and allows to register the progress of every student in each session.

Each teacher must specify his/her tutorial schedule as well as the place (or e-communication tool) and kind (virtual or traditional, i.e. face-to-face) of tutorials. The system also permits specifying scheduled tutorials, which are special sessions established for specific purposes.

The possibility of add notices relating to their subjects allow teachers to notify their students about any topic, as could be a tip for a close laboratory session, a change in the schedule or the publication of a new relation of exercises. Each teacher can read the notices concerning to him/her, sent by the system administrator or any other teacher of any shared subject.

As registered users, teachers can use an internal messaging system that allows them to send/receive messages to/from other registered members of the platform, without knowing their e-mail addresses. If teachers filled an e-mail address in their personal e-card, the system forwards messages as e-mails to that account, avoiding in this way the need to visit the platform to read them.

Teachers can also insert new links into the public section *Links*, but inside an existent category. They are not allowed to add any other category to it. They can modify the links they introduced too, to update or correct misprints.

C. Student

Every student selects the laboratory group in which he/she wants to be registered through the platform, from the list of offered groups. Previously, the teacher must have introduced his/her data into the corresponding theoretical group. Students can change this selection during the period established for registering, if they do not like their initial selection.

There is a download area for every (theoretical and laboratory) group registered into the system, where the teachers in charge of a group upload working material, such as exercises, solutions, classroom presentations, etc. Only students registered in that groups can access this material.

The system also allows students to send their works thought the platform. Previously, the teacher must have introduced the students' tasks. When a student decide to send the solution of one of them (one or more files), he/she must choose one work from the list of pending work and upload the corresponding files. Immediately afterwards, the system will mark it as sent. This make possible to the student to be aware of the correct sending of his/her work, and to the teacher to have an automatic register of work reception.

The system shows to every student only his/her grades, and never any other student ones. This protects the rest of students' data privacy. However, the system gives contextual information about grades, which allows each student to compare his/her marks with his/her classmates ones. The system presents the position each student is ranked in three contexts: in the group (taken into account only his/her classmates), in the subject (taken into account all its groups) and by the teacher who marks the exam (attending to all the exams marked by the same teacher, who may not coincide with the

teacher who teaches each student). This tool shows individual observations or comments the teacher wishes to communicate individually to the students regarding that grade (for example, telling a student he got a better mark due to the volunteer work he did). Additionally, the system also shows the general information about the examination session, which may include the schedule for checking the exam results. The system allows to filter grades by subject and academic years. It has an additional option to generate a printed version for all that information, which is useful in the case the student wants to have a copy on paper.

It is students' responsibility to update their own electronic card. This card is only available to their teachers. Each student must update data contained in it, such as postal address, e-mail or phone number, among others. There is a card section where the system shows the subjects the student is registered in, as well as the ones he/she has been registered in (using the platform).

As registered users, students are allowed to access different communication channels for contacting any other system user. For example, they can access the discussion forums relating to their subjects, or use an instant messaging system. They also have an internal mail account to receive messages from platform users. In a similar way to teachers, students will receive their internal mail into the e-mail account established in their cards.

As they are authenticated as students, the system will let them to read all the notices addressed to any subject they are registered in too. The system let the user to filter notices listing them by date, grouping them by subject, or choosing only those related a specific subject.

D. Administrator

The system administrator is responsible for inserting, updating and deleting first level information. Only a person playing this role can register and unregistered teachers, subjects and degree courses into the platform. The system administrator has absolute control about the storage system, being able to do any operation in the system, even though it is not his/her competence. This allows him/her to be able to correct any kind of mistake made by the actual responsible person.

Regarding the insertion of subjects into the system, the administrator must provide their basic information, and assign them their corresponding teachers, choosing among them the coordinator of that subject. Previously he/she must have registered all those teachers to let them access to the platform and operate from their teacher role. Likewise, he/she must insert the degree course each subject belong to and the center (faculty) in which it is taught.

This role is the unique which is allowed to create new categories in the public section *Links* and to establish the order in which categories and links inside each category are shown.

IV. TUTOR ACCEPTANCE BY STUDENTS: RESULTS OF A SURVEY

We were interested in the opinion of the students who used Tutor, and asked them to complete an anonymous and voluntary on-line questionnaire (<http://tutor.ugr.es/formulario.php>,

in Spanish). We collected 308 valid responses and analyze the frequency distribution for each questionnaire item using the statistical package SPSS version 12. An independent sample t-test [11] was used to determine whether there were significant differences regarding gender. Statistical significance was set at 0.05 for all statistical analysis. The questionnaire was organized in two parts: The first one is a general section whose aim is to determine the user profile and obtain information about technological and web uses. The second section studies the use that students make of Tutor tools and examines whether some academic activities are more comfortable using Tutor than in a traditional way. We obtained the following results:

A. Student profile

- Among the participants, 43.3% were male and 56.7% were female, belonging to four academic degree courses: marketing, economics (both degrees with less than 10% of the whole population), management (34.4%) and business (48%).
- The age ranges from 18 to 38 years old (Mean = 21.9 years; Standard Deviation = 2.64 years) and three subsets of respondents in the population can be distinguished: students under the age of 21 (representing 44% of the whole population), participants aged 21 to 25 (48.3%), and students over 25 (7.4%).
- Students of the survey can be considered as ICT users because:
 - ◆ 92.5% of the students had a computer, most of them with an age ranging between one and four years.
 - ◆ The frequency of Internet use is mainly daily. It was found that 40.3% of the students used Internet every day and 54.5% connected from home. This therefore explains why the majority of Tutor location usage was also at home, with a score close to 42%.
 - ◆ The percentage of people owning a printer was over 82.5%; 46.6% had a scanner, and more than half the population had digital cameras (53.2%) or mobile phones with camera (55.5%).
 - ◆ Although both groups, male and female respondents, have similar scores relating to new technology, it was found a statistical difference in computer (p -value = 0.031; $\hat{p}_M=0.96$; $\hat{p}_F=0.9$), scanner (p -value = 0.033; $\hat{p}_M=0.53$; $\hat{p}_F=0.41$), and digital cameras owners (p -value = 0.034; $\hat{p}_M=0.6$; $\hat{p}_F=0.48$).

B. Use and comfort of Tutor

- All of the different tools provided by Tutor were used, and more than a half have been considered positively with scores over 64%. Fig. 2 shows the corresponding percentages of use.
- Concerning the use of the services, analogous scores were found between male students and their female counterparts, with only a statistical difference in the responses to the question “use of the download zone” against female use (p -value = 0.021; $\hat{p}_M=0.74$; $\hat{p}_F=0.61$).

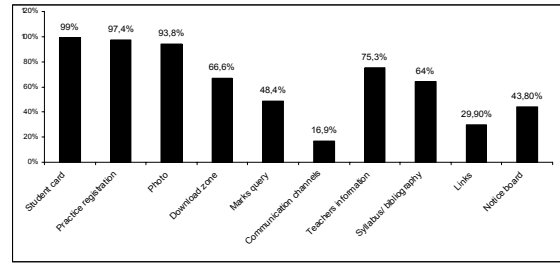


Fig. 2. Use percentage of some Tutor tools.

- We think that using Tutor in some different academic tasks is more comfortable than carrying out the same activities without it. And that seems to be true if we look to Fig. 3, which shows the percentage of students who declared that they preferred Tutor to the traditional way for some academic tasks.

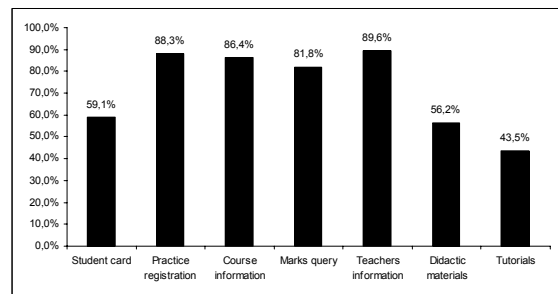


Fig. 3. Students preferring Tutor to the traditional method for several academic tasks.

As we can see, all actions are considered more comfortable if they can do it with Tutor. Only in tutorials the traditional method is preferred to Tutor. In our opinion the reason is connected with the existing culture at university, which is now beginning to change.

- One more time, male students obtained significantly higher scores than female students both for the student e-card (p -value = 0.000; $\hat{p}_M=0.72$; $\hat{p}_F=0.49$) and for obtaining didactic materials (p -value = 0.002; $\hat{p}_M=0.66$; $\hat{p}_F=0.49$), comparing with the traditional system.

In conclusion, data confirm Tutor can be a good instrument for students in their academic purposes.

V. CONCLUSIONS AND FUTURE WORK

We have presented a role-based model which has been applied to the development of a web system to support teaching, learning and academic data management relating to subjects at University of Granada. We have enumerated the main components of our toolset and shortly described the architecture and operations of our platform, and the services it provides.

We have also presented an analysis of student's opinion (collected by a survey), trying to find the main use differences between user groups (i.e. differences according to gender), and their opinion with accordance to replacing the traditional method with Tutor. The results show that there are no meaningful differences between the platform users, and the majority of tools have been widely accepted among students, displacing the traditional use as preferred method.

Consequently, we think that the platform is a good tool for supporting many of the academic activities and for encouraging the active participation of students in their learning process. However, there are some functions that must be improved, or which require to make things easier.

In future works we will improve aspects relating to navigability and adaptation to users, in order to make easy the use of Tutor. Moreover, we want to improve some particular aspects, e.g. to provide a better system to carry out virtual tutorials.

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The eChalk System: Potential of Teaching with Intelligent Digital Chalkboards

S. Jeschke, L. Knipping, O. Pfeiffer
Berlin University of Technology,
Department of Mathematics and Natural Sciences,
TU Berlin, MA 7-2, Straße des 17. Juni 136, D-10623 Berlin
{sabina.jeschke, knipping, pfeiffer}@math.tu-berlin.de

Abstract—eChalk is a software system that transforms an electronic whiteboard into a teaching tool simulating a traditional chalkboard. In addition to writing and drawings, the electronic chalkboard handles a wide range of multimedia enhancements. These may be used to enliven the lessons by visualization, allowing the system to surpass the didactic potentials of the traditional chalkboard. The system records all actions and provides both a live transmission and a replay of the lecture from the web as a by-product of regular classroom teaching. Remote students follow the lecture by watching the dynamic board content and listening to the recorded voice of the instructor. While originally created only for the use in the Western hemisphere, recent developments target the support of teaching in the Middle East. From our point of view, advantageous application in particular for teaching in different cultures is characterized. This is especially true for cultures with non-Latin scripts and regions which lack the infrastructure for high-speed Internet connections. Systematic evaluations from regular use at two universities are presented.

I. INTRODUCTION

Nowadays, it is common in university teaching to rely on the use of slideware (such as Microsoft PowerPoint) for additional motivation of students by providing a modern touch to their lectures. New teaching materials can be produced with relative ease, providing a professional, polished look, while publication is simultaneously simplified, both electronically or as hardcopies. Once created, the materials can be quickly and easily reused.

However, the employment of slideware products in teaching has also been heavily criticized [6]. These products have been developed for commercial presentation purposes. It has been argued that they are well-suited to the task of “selling” a product or idea but tend to be inadequate for presenting complex arguments [15],[16].

Also, the human brain can be easily overloaded by the sensory input that e-learning and multimedia technology is capable of delivering [5]. Even though such tools can be used to give an easy-to-follow lecture when correctly employed, they do foster a tendency to overwhelm learners with an overly rapid presentation of information. Lecturers, naturally, possess a deeper understanding of the subject and often tend to

proceed through the lecture at a pace too fast for their students to follow. Traditional teaching using a chalkboard imposes a natural limitation on the pace that is overcome through the use of slideware. Also, classes given with slideware tend to be far less flexible and spontaneous than more traditionally presented ones. To use the words of a university lecturer, “PowerPoint sucks the life out of a class” [2].

Some approaches try to address this situation by adding annotations to slides. Office XP now features annotation tools in PowerPoint. Classroom Presenter streams a combination of PowerPoint slides and freehand “inking” [3]. The “eClass” (later “Classroom 2000”) software is an early example of recording snapshots of annotated slides and electronic whiteboard drawings for distance teaching purposes [1].

Looking instead for established teaching techniques, one finds that the old-fashioned chalkboard has been an unsurpassed teaching tool for ages. The board ensures that information stays available, providing context for further discussion. The learners can see how ideas are developed rather than being overwhelmed with final results and are supported in following the conceptual process. The teacher is slowed down to the speed of his or her handwriting, giving the students time to follow his or her train of thought.

Compared to the use of prepared slides, the “chalk and talk” approach allows for a much more flexible teaching style. Working on a chalkboard supports creative thinking, illustration, and sharing. Board drawings can be used to draw attention to details using circles, arrows, underlines, checks, groupings, etc. The inherent impreciseness and vagueness of freehand drawings holds extra information. Given these outstanding qualities for teaching, it comes as no surprise that the chalkboard is still so popular for teaching in many disciplines, especially for subjects where complex reasoning has to be taught, such as mathematics, engineering, and the natural sciences.

II. LECTURE RECORDING

Using conventional authoring systems, creating e-learning material is a laborious process. Production costs are estimated

to range from 50 to 200 man hours for one hour of learning content. Generally, this is economically not viable unless the content is either aimed at a very large audience or can be reused many times. For the teaching at universities, the situation is particularly grave, as the contents taught tend to change very fast.

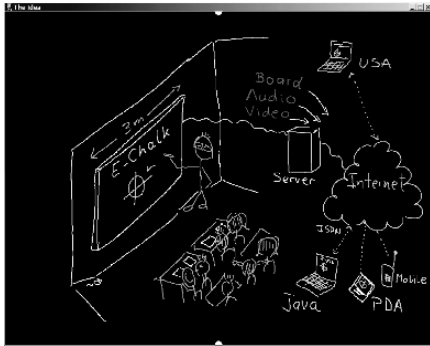


Fig. 1: eChalk's idea as an eChalk sketch.

A cause for this tremendous effort lies in the fact that traditional teaching know-how does not easily match with contemporary authoring tools. Apart from technical effort it requires a huge amount of work to structure didactic content for the Web, even if presented only linearly.

Trying to avoid the expenses of standard e-learning module authoring, many universities resort to video capturing of their standard lectures. This approach has the advantage of making use of existing teaching qualifications of the lecturer, instead of requiring the lecturer to acquire new teaching skills. If the lecturer feels comfortable with being video-taped and the recordings manage to transport the feel of the lecture, they can produce high-quality teaching as a kind of by-product of traditional teaching.

However, this approach does not only requires technicians present during the recording to handle the camera and the audio hardware, but most standard Internet video web cast tools are inadequate for this kind of content. Writing and drawings, on slides or on a blackboard, are not encoded appropriately. Compression of a single video frame with off-the-shelf video encoding technology relies on dropping the higher-frequency parts from images resulting in the loss of sharp edges. Either the content becomes blurred and unreadable or, using only weak compression, the video stream requires a lot of bandwidth.

A. Our approach

These considerations inspired the development of a system called eChalk [9],[10]. During classroom teaching, the lecturer works directly on a pen-active wall display or uses a digitizer tablet, see Fig. 1. A good chalkboard lecture should automatically result in a good e-learning lesson. The goal is to preserve the pedagogical advantages and the easy handling of the traditional chalkboard, while extending its reach to

distance learning. While the eChalk interface is based on the metaphor of the simple chalkboard, it is enriched by a wide range of multimedia enhancements. These may be used to enliven the lessons, allowing eChalk to surpass the didactic potentials of the traditional chalkboard.

All actions on the board are tracked. The development of the board content can be viewed by a remote learner, both as a live transmission or as an asynchronous replay. The voice of the lecturer can also be recorded. The distance learner is provided with a dynamic script of the class where none of the teacher's side notes are lost. These two data streams already capture most of the substance of the lecture. Optionally, a video stream of the instructor can be added to provide a more personal touch to the remote lesson and enable the viewer to observe the lecturer's mimics and gestures.

The system is not designed to replace teaching in the classroom. The recordings should "capture the live experience" of the lecture's natural flow, as well as having the teaching style influenced by interactions with a learning audience. The approach merges classroom teaching, distance teaching, and the production of courseware into a single task.

III. THE ECHALK SYSTEM

A. In the lecture hall

In order to use the eChalk software in the classroom, one needs a pen based input device and a wide display. Usually, one of the three alternative device configurations is used, a digitizer tablet or tablet PC with an LCD projector (see Fig. 2), a digitizing whiteboard or a retro projector with pen tracking.



Fig. 2: Mathematics lecture at Berlin University of Technology using a digitizer tablet and LCD projector.

Having started eChalk, the system's user interface metaphor changes from a computer desktop to a chalkboard. The mouse is replaced by a pen-like input device and the need of using the keyboard is avoided wherever possible. The software transforms the screen into a black surface where one can draw or write using different colors and pen widths. The board can be scrolled up and down vertically, providing the lecturer with a virtually unbounded surface to write on. Instead of using a desktop-style scrollbar, two white *drag handles* are provided at the top and at the bottom of the screen, see Fig. 3. The user grabs the board at a drag handle using the pen and drags the board up or down.

The lecturer may embed images from the web or the local storage devices and annotate them. As a much more sophisticated feature, computer algebra systems (such as Mathematica or Maple) working in the background can be queried for their numeric or symbolic results or even for function plots, all seamlessly integrated into the board drawings, see Fig. 3. A mathematical formula recognition allows these requests to be input conveniently in handwriting, including such complex objects as differential operators, integral symbols, vectors, and matrices [10],[14].

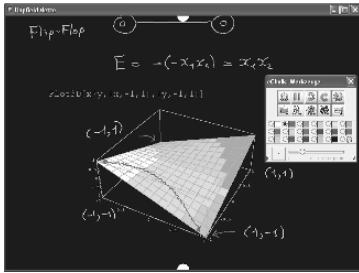


Fig. 3: A lecture containing a plot from a computer algebra system.

The lecturer can also send queries to dynamic web services (CGI scripts) returning text or pictures. Interactive Java Applets can be run on the board to provide visualizations for abstract topics and concepts. Alternatively, custom eChalk modules called Chalklets can be used. These are controlled by means of strokes of the pen on the board and return drawing strokes themselves, preserving the board-like look and feel. For example, a logic circuit simulator [12] recognizes sketches of digital circuits and runs a simulation, color-coding the wires to indicate high or low voltages, as shown in Fig. 4.

The system does not require the user to explicitly trigger a save. Everything is automatically and continuously stored for viewing through standard web browsers.

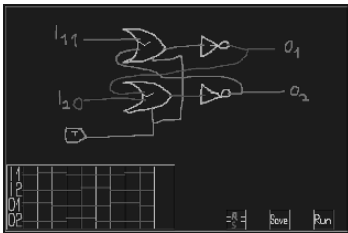


Fig. 4: Simulating a clocked RS Flip-Flop.

B. Remote usage

When remote students open the automatically generated web page of a given course with a browser, replay starts in the form of self synchronizing Java Applets. One Applet is started for every data stream present: board, audio, and video. An additional Applet, the control panel, is provided for navigation

in archived lectures, see Fig. 5. All these Applets run in a standard Java-enabled browser, without requiring the download of a special plug-in. Audio and video is streamed using lossy compression and buffering to guarantee interruption-free transmission. A printable, static copy of the final board image is also included as an Adobe PDF file.

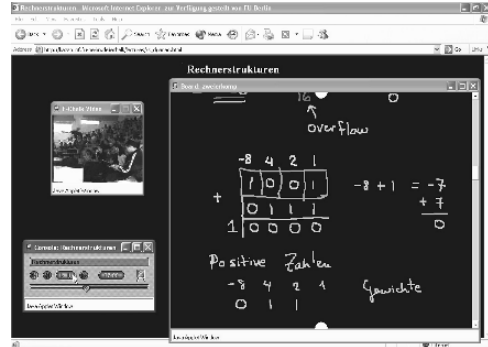


Fig. 5: Replay of a recorded eChalk lecture as seen in a browser.

IV. USE IN DIFFERENT CULTURES

The eChalk system relies on the audio signal captured from the lecturer combined with his or her freehand writing and drawings as board input. This does not only enable the lecturer to input complex mathematic formulae much more conveniently than using a standard formula editor, a usually rather cumbersome task. It also makes the input completely independent of the writing system and language used, whether it relies on the western alphabet or Arabic script or other sign systems, instead of forcing the learners to work with a writing system other than their native one.

Most parts of the user interface rely on icons and graphical elements, see Fig. 3. Only the recording setup uses printed information to a greater extent. However, the overall user interface of eChalk has been localized to several languages including Arabic, see Fig. 6. A translation to simplified Chinese is currently under way.

From the very beginning, eChalk transmissions were designed to impose only low technical requirements on the users. This provides an extra advantage in areas where the Internet infrastructure available does not allow requiring students to have a broadband connection. Due to the board stream using a vector representation, the bandwidth requirements are very low. The bandwidth of the board stream peaks in the range of 3 to 5 kbps when using standard pen or mouse devices, i.e. with sampling rates between 50 and 125 Hz. In fact, average bandwidth needed in real lectures turned out to be less than 1 kbps [11].

Therefore in practice, the board's bandwidth requirement is negligible compared to the bandwidth used by audio (and optional video), particularly since audio stream codecs between 24 and 256 kbps can be chosen. Again, these

numbers are maximum values rarely reached and only for a few seconds. Choosing the 64 kbps codec allows remote access to a board and audio stream of sufficient quality with only a modem connection.



Fig. 6. Setup dialog for an eChalk recording localized to Arabic.

V. EVALUATIONS

The development of eChalk has been guided by experience from ongoing deployment of the system in regular university teaching for several terms now. A number of field studies have been conducted in the course of university courses to evaluate the use of eChalk, its impact on teaching, and its acceptance under real-life conditions [11]. These studies were arranged by media psychologists from the Freie Universität Berlin and Technische Universität Berlin (Schulte, Issing and Hendricks). The courses included lectures and exercises on mathematics for engineers, physics for engineers, computer science as well as seminars on cartography. For computer science courses, replays with audio and PDF transcripts were provided. The cartography seminars used the system for classroom teaching only. The engineering courses provided replays without audio recordings and PDF transcripts.

During the 2003 summer term, six eChalk courses were evaluated. Data gathered included 595 full questionnaires, filled out at the beginning and end of the term, 893 short questionnaires filled out during the final exam, interviews with the six instructors, and Web access analysis for one of the courses [13]. In a second study conducted during the winter term of 2003/04, 303 questionnaires from nine eChalk courses were evaluated [8]. In the following the main findings are presented. A detailed summary of these studies can be found in [11].

A. Findings from student questionnaires

Adopting eChalk in teaching did reveal neither positive nor negative effects on the students' motivation to prepare for the lecture. Didactic quality of the courses was perceived positively compared to regular courses. Students welcomed the extra flexibility in learning, both for increased independence in time and in location.

The students were asked to judge the impact of the system on their studies, whether it helped in or complicated learning. The answers showed a clearly significant tendency towards a

positive impact.

About half of the students (46.8%) reported using the eChalk materials regularly for revising the classes. The average time spent revising including the "zero minutes users" was 19 minutes per week. Considering only those students who actually use eChalk for revision, the average was 40 minutes, the median 30 minutes. However, these figures should not be taken too literally, as they display a high degree of variance.

Asking students about the amount of note-taking in eChalk classes compared to regular classes yielded results differing between the two studies. The first study showed a small tendency (below statistic significance) of students reducing the amount of note-taking compared to regular courses. According to the second one, about 60% of students were taking at least as many notes in eChalk classes as in conventional classes.

The short questionnaires coupled with the exam in the summer term study were used to compare exam results and eChalk use. However, no significant correlation between exam results and eChalk use could be found. In all user categories almost the same grade has been achieved. [14] suggests further examination by forming two groups with the same external conditions differing only in the use of eChalk.

The first evaluation also examined the students' opinions on the quality of the system. The answers concerning the visual impression showed a slight tendency towards a favorable opinion, with no significant differences between classroom teaching and replay. The acoustic quality of the instructor's voice, however, received below-average ratings for the replay. This result was a major motivation to enhance the audio recording quality in eChalk by the approaches described in [7]. Despite the shortcomings in audio quality, the overall quality of the system was clearly seen as positive, both in classroom teaching and in replay. Using eChalk in the evaluated course received above-average marks from 73% of all students.

To compare eChalk with other teaching techniques, the students were asked to judge, in comparison, between eChalk-taught classes and classes using other teaching technologies. The comparison was made on courses using electronic slide presentations like MS PowerPoint, traditional chalkboard teaching, and overhead slides. eChalk was favored above all these three teaching media, with PowerPoint coming closest and overhead slides ranging last, see Fig. 8.

Students' use of eChalk-generated material was found to be uncorrelated to the bandwidth of their Internet connection and their preferred type of browser. Thus, it can be assumed that eChalk recordings are equally usable with any type of connection.

The students were asked to provide comments on the advantages of the eChalk system, on its disadvantages, and on suggestions for improvements.

The most frequently mentioned advantage was a clear, readable board image, followed by comments on remote access, revision material, enhanced visualization through the

use of applets and images, the elimination of the need to copy the board content, providing the learners with more time to concentrate on the content of the lecture. A few students also noted that the lecture was easier to follow with the system.

Commonly mentioned disadvantages include complaints about the visual quality of the board image, the relative size of the board, and the bad handwriting of the instructor. A likely cause for these shortcomings is the low resolution of the displays used, forcing the instructor to write larger letters for improved readability. While the digitizer hardware describes in Sect. III.A is theoretically capable of recognizing the pen's location far beyond the accuracy of the human hand, the resolution is limited by the screen resolution of the projector and the controlling computer's graphics card. However, organic displays might solve these problems, as very wide, high-resolutions screens are expected within the next few years [4].

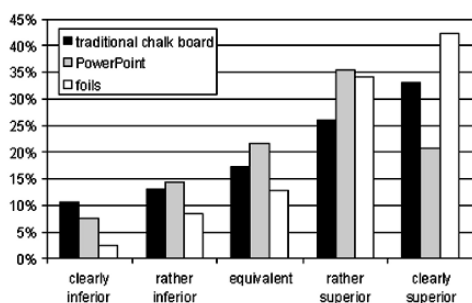


Fig.8. Students' opinions on teaching with eChalk compared to using other types of lecturing tools: to traditional chalkboards, to PowerPoint, and to overhead slides.

Almost all comments on possible improvements were requests for features which were already fully supported, but not used in the evaluated lecture.

B. Findings from instructor interviews

According to the lecturers interviews, the time needed by lecturers to get fully accustomed to the system, ranged between one and four lectures. [13] judges this as an indication for the intuitive handling of the software. The interviews also showed that most features beyond the basic writing features and use of images were rarely used.

The instructors' comments on advantages and disadvantages of the system were similar to the most frequent students' comments. In addition, they judged as positive that the teaching content of traditional classes needs no restructuring when presented with the system, enabling them to reuse their old materials. Some lecturers mentioned that they missed the small pauses introduced in traditional chalk lectures by the wiping of the board.

VI. SUMMARY

Experiences in using the system in actual teaching and

systematic evaluations confirmed the potential of eChalk as a beneficial and usable system for teaching. The lecturer can easily integrate material from previous terms. Traditional chalkboard-related skills translate directly into skills for good eChalk lectures.

The system enables the user to produce electronic course materials simply as a by-product of classroom teaching. Students are supported in their revision of classes with a live and dynamic "transcript". Only a browser is needed for this and no special software has to be installed. All substantial content of the lecture including audio and dynamic board image can be received with low bandwidth requirements.

The system presented here not only tries to preserve the didactic potentials and easy handling of the traditional chalkboard. Its reach is extended to extensive use of new media and remote access, enhancing the quality of teaching in mathematics and engineering education, and fostering understanding through interaction and visualization.

Field studies conducted so far covered university teaching only in a Western setting. While the system provides the technical requirements to teach in other cultures, impacts of different learning habits still have to be researched. For example, the importance of the different content channels board, audio, and especially video might be very different in other cultures. The importances of aesthetic writing in Far Eastern cultures, the cultural outlook on lecturers as persons of authority, or forms of etiquette are only some of the potentially influencing factors.

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On Remote and Virtual Experiments in eLearning in Statistical Mechanics and Thermodynamics

S. Jeschke, T. Richter, H. Scheel, & C. Thomsen
Technische Universität Berlin

Department of Mathematics and Natural Sciences, Center for Multimedia in Education and Research
Straße des 17. Juni 136, 10623 Berlin, Germany

The science of physics is built on theories and models as well as on experiments: the former structure relations and simplify reality to a degree such that predictions on physical phenomena can be derived by means of mathematics. The latter allow to verify — or falsify — these predictions. Computer sciences allow a new access to this relationship, especially well-suited for education: New Media and New Technologies provide simulations for the model, virtual instruments for running and evaluating real experiments and mathematical toolkits to solve equations derived from the theory analytically and to compare the outcome of all three methods. We will demonstrate this approach on two examples: Ferromagnetism and elementary thermodynamics.

I. INTRODUCTION

One of the intellectual challenges when learning physics is to understand the role of a physical theory, the role of a physical model and the role of an experiment. Often, these terms are intermixed, and the classical curriculum offering separate lectures for theoretical and experimental physics does not make it easier for students to really comprehend their inter relation.

Modern eLearning technology may act as a bridge: On the one hand, computer systems make real experiments available over the internet, any time, anywhere, and — even more important — make the measured data electronically available for further analysis. On the other hand, a model for an experiment can be implemented as a simulation within a virtual laboratory, making the same physical quantities available for measurement as in the “real” experiment. It is now straight forward for a student to compare the outcome of the two approaches and to compare them again with an analytic result of a physical theory. Thereby, similarities and differences between the theory, the model and the experiment can be demonstrated and analyzed.

In this paper, we discuss two important physical systems: First, the physics of ferromagnetism and the Ising model [6] as the most prominent system of statistical mechanics. Second, the physics of ideal gases, and, as the corresponding theoretical model, the lattice gas model [3, 4] to discuss the concept of entropy phenomenologically as well as statistical thermodynamics.

II. A BRIEF INTRODUCTION TO THE PHYSICS OF MAGNETISM

Materials react differently to an applied external magnetic field: they are either diamagnetic, paramagnetic or display

effects due to the correlations of magnetic moments in the material, such as ferromagnetism or antiferromagnetism. [2, 7]. Diamagnetism and paramagnetism are weak and require relatively large external fields to make them visible. Ferromagnetism, however, is apparent for small external fields: Unlike dia- and paramagnetism, it is a many-body phenomenon where the elementary magnets of an otherwise paramagnetic material interact with each other and couple their magnetic moments such that a macroscopic field is generated. The magnetization M of the elementary magnets in the material adds up with the external magnetic field H to the magnetic induction B [7].

Two properties are now interesting about M for ferromagnetic media: First of all, there is no unique relation between H and the induced magnetization M , but M depends on the history of the process. Ferromagnetic materials show a hysteresis, and a plot of the magnetization over the magnetic field has a typical double-S shaped form. Second, the ferromagnetic effect vanishes for high temperatures: If the temperature T becomes larger than the Curie-temperature T_C , ferromagnetic materials become paramagnetic and the hysteresis vanishes, thus establishing a phase transition, similar to the solid-liquid phase transition observed for water when melting.

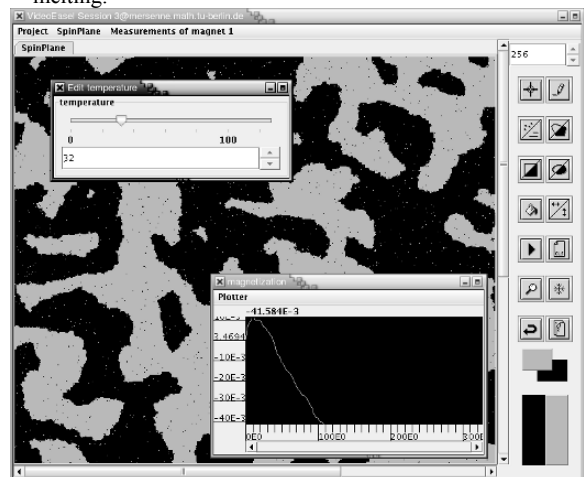


Figure 1. The Ising Model in the virtual laboratory VideoEasel

Ernst Ising developed in the 1920's [6] a microscopic model to explain ferromagnetic behavior. According to

which ferromagnets consist of elementary magnets called spins, carrying magnetic moments — in the simplest possible model — pointing into one of two possible directions. They interact with their nearest neighbors in such a way that the energy contribution of a spin-spin pair to the total energy is minimal if the two neighboring spins have parallel magnetic moments, and maximal if they are antiparallel. Even though Ising's first attempt to show a phase transition in a one-dimensional spin-chain failed, a two-dimensional model did reproduce all macroscopic effects. A rigorous proof of this model was given by Onsager many years later. [12]

III. MAGNETISM IN VIRTUAL LABORATORIES

The Virtual Laboratory VideoEasel developed at the TU Berlin focuses on the field of statistical physics and statistical mechanics [8, 13]. Implementing a freely programmable cellular automaton [16], VideoEasel is capable of simulating various models of statistical mechanics and related fields.

Measurements are performed by tools freely plugged into the experiment by the user, allowing to observe magnetization, entropy, free energy or other measuring quantities. When experiments of higher complexity are performed, the experimental results can be automatically exported into computer algebra systems for further analysis. To enhance cooperative work between students, or students and their teachers, VideoEasel is able to support distributed measurement processes on the same experimental setup, including remote access from outside the university [8].

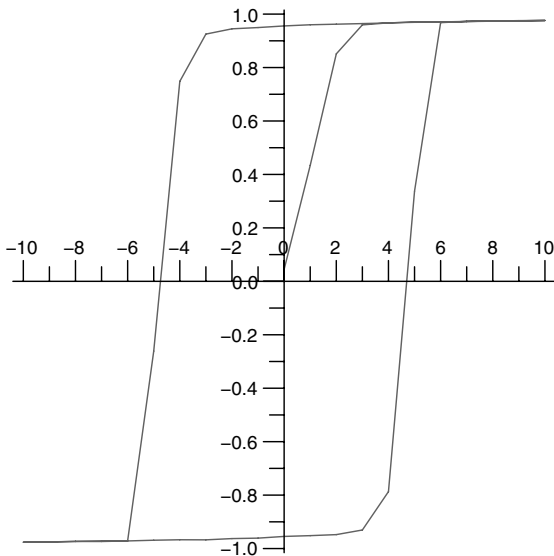


Figure 2. Hysteresis loop of the Ising model for low temperature

To investigate the Ising model, VideoEasel implements the Metropolis dynamics [11], see Fig. 1: A spins is drawn at random, and flipped if either the overall energy of the model decreases after the flip, or the energy can be borrowed from

a heat-reservoir. The user is able to control the temperature T and external field H and then measures quantities as the magnetization M . If we plot the relation between M and the field H for low temperature, a hysteresis loop is found, see Fig. 2. For high temperatures this figure vanishes.

Additionally, our model allows us to measure an additional parameter, namely the Helmholtz Free Energy F [14]. This quantity is phenomenologically defined as the fraction of the overall energy of the model that is available for mechanical work. If we measure M and F , each depending on H , while starting from a random spin configuration, we get the graphs shown in 3. It is now easy to conjecture for our students that M must be proportional to the negative derivate of F with respect to H . After having seen that, our students easily derived this from the Gibbs state of the Ising model [14], and thus our experiment was also didactically successful.

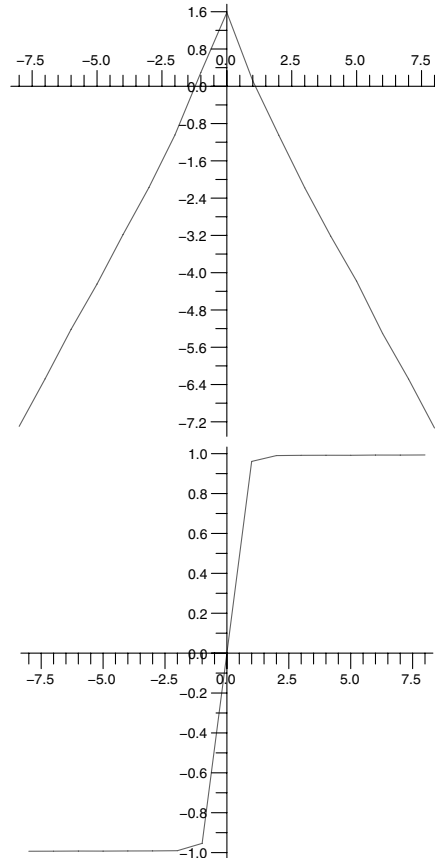


Figure 3. Free energy (top) and magnetization (bottom) as functions of the external field

IV. INVESTIGATING HYSTERESIS IN REMOTE EXPERIMENTS

Complementary to Virtual Laboratories, Remote Experiments are real experiments, remotely controlled by the student from outside the laboratory. A Remote Experiment consists of two vital parts, namely the experiment itself and a computer interface allowing control over the experiment via the internet. For the latter, we use National Instruments LabView [5], which also provides a convenient web-interface. In order to view and control the experiment, a freely available web browser plug-in has to be downloaded and installed. Due to the modular programming structure of LabView, remote experiments can easily be combined or extended [15].

We can now run the same experiment, namely that of measuring the hysteresis loop of magnetization vs. magnetic field, in reality: a magnetic coil generates a magnetic field H that is proportional to the current passing through it, which is controlled by the computer. The magnetic field magnetizes a ferromagnetic core. The Magnetic induction B is measured by a Hall probe, see Fig. 4. The measured value is then digitized by an analog-digital converter that provides a digital output port, and by that made available from the computer system.



Figure 4. Setup of the remote experiment on hysteresis, the magnetic coil in the middle, Hall probe in front

V. VIRTUAL LABORATORIES & REMOTE EXPERIMENTS: SIMILARITIES AND DIFFERENCES

At first glance, both the experiment and the model show the same hysteresis effect: the relation between magnetization and magnetic field cannot be represented by a function. However, a student running both types of experiments will note that the exact shape of the hysteresis loops is very different: Whereas the Ising model shows an almost rectangular shape, cf. Fig. 2, textbooks typically show an S-shaped form. But even the usual graphs found in textbooks do not always depict reality correctly: The hysteresis loop has a small area, see Fig. 5. Thus experiment and model do not agree completely. There are also deviations between model and theory: When taking the numerical derivative of the free energy, the curve looks almost, but not quite like the magnetization plot: The derivations are best seen for small fields. This is likely because our entropy measurement is only an approximation and does not take long-range interactions into consideration.

Students, in this way, learn that models are by their very nature incomplete, and theories make approximations and can only predict reality within a certain error.

VI. A BRIEF INTRODUCTION TO THERMODYNAMICS

Thermodynamics is the physics of temperature and heat. As a phenomenological science, it formulates the relations observed between physical observables. For example for the ideal gas the product of pressure and volume is proportional to the temperature. Thermodynamics does not attempt to derive these relations from a microscopic theory.

Even though these relations are obvious to verify in an experiment, thermodynamics also formulates laws that are harder to verify experimentally. The most prominent example is the second law of thermodynamics, first formulated by Clausius [1], which states the existence of a thermodynamic potential called the entropy, which cannot increase in closed systems. One of the consequences of this law is that thermodynamic processes, e.g. combustion engines transforming heat into mechanical work, must have a limited efficiency strictly below 1. Said another way, it is impossible to convert heat energy into mechanical work without any loss [14] for temperatures $T > 0$.

Since entropy is a rather abstract concept that cannot be measured directly, this law is, almost traditionally, hard to motivate to students. Some textbooks even joke that “students usually only believe this law because they wouldn’t otherwise pass their exam” [2].

VII. PHENOMENOLOGICAL THERMODYNAMICS IN THE REMOTE EXPERIMENT

To demonstrate the classical gas laws, our remote experiment farm also includes an experiment on thermodynamics, see Fig. 6. A motor controls the position of a piston in a glass cylinder containing air whose temperature can be remotely adjusted by a heater. Sensors measure the pressure of the gas and its temperature. Their measurements are digitized and

made available over the internet. Given this setup, students can readily verify the classical laws of phenomenological thermodynamics, for example the Gay-Lussac relation between volume and temperature.

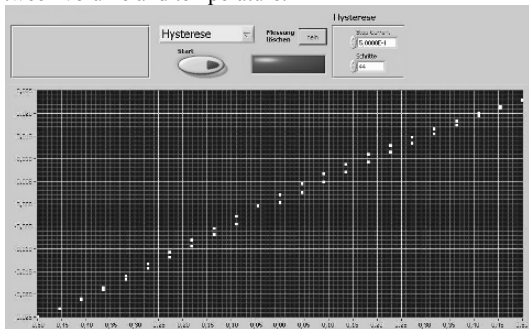


Figure 5. The hysteresis loop, as found by the remote experiment

However, one can clearly go beyond this experiment: By controlling the heater and the piston, students can run the system in a thermodynamic cycle process. The amount of heat energy induced is known due to the characteristics of the heater, and the amount of mechanical energy made available by a cycle can be computed from the area within the pV diagram [2] as measured, see Fig. 7. Comparing the two readily presents the limited effectiveness of the process, and demonstrates one of the consequences of the second law of thermodynamics.

VIII. LATTICE GASES IN THE VIRTUAL LABORATORY

Lattice gases are simple, discrete models for ideal gases defined as cellular automata [16], and as such easily implementable in our virtual laboratory. Within HPP model used by our setup [3, 4], the gas consists of elementary particles, atoms called in the following, which can only travel in four diagonal directions within two-dimensional space. Collisions with boundaries and between atoms preserve energy and momentum.

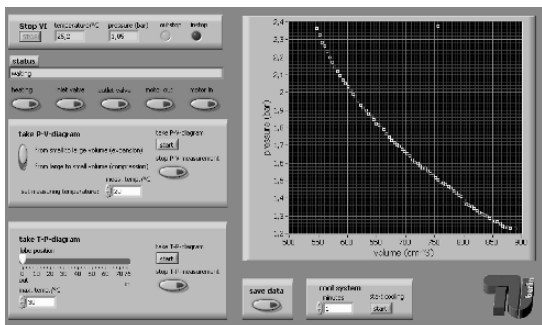


Figure 7. A pV diagram, as measured by the remote experiment

Unlike in remote experiments, we are now in a position where we know the microscopic state of the system exactly, and are thus able to measure the entropy. In a simple ex-

periment, a student fills one corner of a simulated gas container with the lattice gas. If the simulation is run, the gas expands into all of the container and the entropy increases except for some small derivation, see Fig. 8.

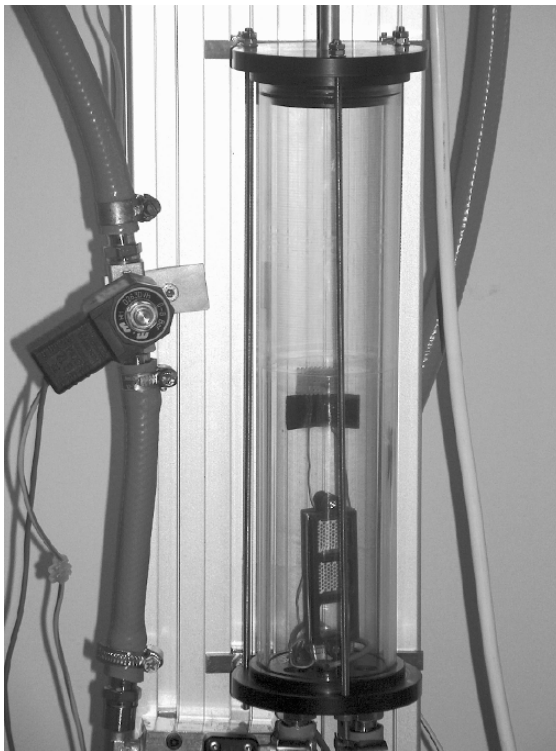


Figure 6. Remote experiment on thermodynamics: A piston (top of the image) controlled by a motor (not shown) compresses gas in a glass cylinder. A temperature and pressure sensor (middle) measure physical observables. A heater (bottom) allows to heat the gas volume.

The monotonicity of the entropy looks even more surprising if we recapitulate that the elementary laws of the HPP gas are completely symmetric in time. The very same argument has been considered historically by Loschmidt as an objection against Boltzmann's H-Theorem [10,9]: Students are now, however, in a position where this objection can be discussed within an experiment, as our virtual laboratory provides means to invert all momenta. Quite as one might expect, gas atoms then move back to their initial positions and the entropy function decreases.

An experiment, whose outcome is as confusing, is well-suited to stimulate a vibrant discussion amongst our students. The resolution is now that the initial state of a gas running back into its container is extremely unlikely and with some guidance, students often come up with an experiment to justify this argument: After modifying the seemingly chaotic state by displacing a single atom by one pixel, we invert the moments of all gas atoms again and observe the entropy and the system behavior again. Even though the en-

ropy starts to decrease for a short while, the system comes no longer close to the initial minimum, and entropy begins to increase shortly after.

IX. COMPARING REMOTE EXPERIMENTS AND VIRTUAL LABORATORIES

It is worth noting that the pV looks again not very much like the idealized curves found in textbooks and is rather noisy. Good textbooks like [2] will of course comment on such specialities. Similar differences often arise in real experiments, as we already found for the hysteresis experiment. They need to be discussed with the students and make up an important part of the education in physics, too.

On the other hand, we also find a tiny discrepancy between the phenomenologically formulated second law of thermodynamics and the corresponding outcome of the virtual experiment: It is not impossible that the entropy decreases, it is just that all odds are against it. Thus, the important lesson to be learned is that the second law makes a statement about the statistics of the system.

The complementary nature of remote experiments and virtual laboratories becomes even more apparent for the experiments on thermodynamics: While the remote experiment is targeted at the phenomenological side of thermodynamics, virtual laboratories allow to explore the statistical mathematical aspect of entropy. Thus, the dual nature of thermodynamical variables such as entropy — being a phenomenological quantity as well as a statistical one — can be explored and demonstrated.

X. CONCLUSION AND OUTLOOK

The accomplishment of experiments in eLearning scenarios touches many aspects — ranging from the actual quantification of a physical measurement over operating experience with real experimental setups to the examination of the corresponding theoretical model — of the learning process in the academic education of natural and engineering scientists. The combination of real experiments with virtual laboratories creates many benefits, of which the most important is that we allow students to study a physical phenomenon throughout experiment, model and theory. We believe that the complementary nature of remote experiments and virtual laboratories stimulates the process of understanding in an outstanding matter, which is vital for the learning process in natural sciences.

Clearly, we still need to extend our experimental possibilities in both the remote as well the virtual laboratories, for example we are not yet able to simulate a moving piston within our virtual laboratory as we would otherwise been able to provide an even closer simulation of the remote experiment and by that could measure pV diagrams in simulation.

Our work will also continue into another direction, namely in trying to perform experiments where virtual and real components interact, for example to compare their outcomes in a common plot within Maple, the mathematical algebra pro-

gram. As both LabView and VideoEasel provide the necessary interfaces to export data, this goal seems to be in close reach.

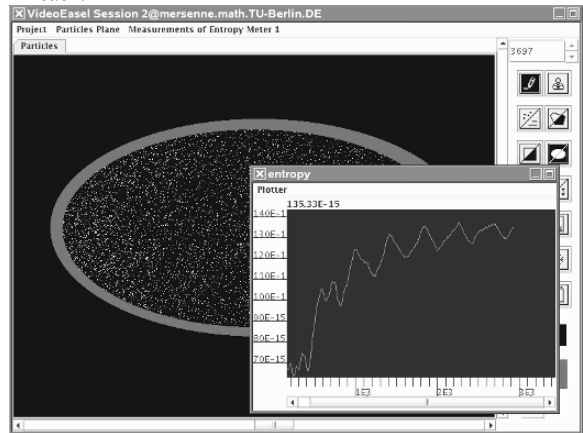


Figure 8. Final state after running the HPP gas for some time. Gas atoms in yellow, the boundary in red. In front plot of the entropy over time.

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Virtual Room Concepts for Cooperative, Scientific Work

Sabine Cikir, Sabina Jeschke, Nadine Ludwig, Uwe Sinha
Technische Universität Berlin

Department of Mathematics and Natural Sciences
Center for Multimedia in Education and Research
Straße des 17. Juni 136, 10625 Berlin, Germany

Abstract - Cooperative knowledge spaces offer new potentials for experimental and scientific work in the current fields of engineering and natural sciences. Widely accepted content management systems often only provide simple content in combination with communication tools; cooperative knowledge spaces are able to project the concept of natural cooperative work onto virtual rooms.

In this article we introduce our concept of virtual rooms for scientific and educational work. We describe requirements for complex cooperative work in virtual knowledge spaces where the rooms are arranged in a dynamic, heterogeneous network and incorporate experimental laboratory equipment, shared whiteboards and version-controlled documents.

We developed this concept in the context of our project “ViCToR-Spaces” (Virtual Cooperation in Teaching and Research for Mathematics and Natural Sciences) and are currently implementing some of the parts of the concept.

Index Terms – cooperative knowledge spaces, virtual and remote laboratories, virtual rooms, cooperative education and work

I. INTRODUCTION

E-Learning is most commonly associated with terms like Learning Management System (LMS) or Learning Content Management System (LCMS). In the last years, these types of learning systems have become widely accepted in educational institutions and companies. They are based on the concept of file systems in a computer. These systems provide a structure of documents, a history, and primarily a suggested thread through the offered material. Additionally, they provide communication interfaces like chats, discussion forums and email. These systems associate content-based learning with communication and sometimes even playful concepts.

However, in “real life” learning as well as research scenarios communication and cooperation play a most important role. Students form work groups to solve scientific problems or perform hands-on experiments together. Cooperation is also an important aspect in scientific collaboration of universities and other research institutions. Scientists of different institutions try to consolidate their knowledge for high-grade achievements in their research areas.

This fact leads to a change of paradigms. In addition to content-based systems, community-based systems are developed. Simple document management is enhanced to cooperative work in virtual rooms. This community-based learning is reflected in cooperative knowledge spaces. In the present article we introduce our room concepts for cooperative knowledge spaces [2].

II. THE CONCEPT OF VIRTUAL ROOMS

A community-based system is composed of multiple rooms offering different functions. The function of a room derives from the number and character of the room’s users, the attached tools and the assigned rights in the room. Different combinations of these components form different types of rooms.

Following this principle, it is possible to design and create rooms for work groups, rooms with teaching material or laboratories with special virtual equipment according to the respective requirements. The users of such a system can decide on their own if they want to work in cooperation with other users or if they just want to solve tasks and study in their own work rooms. In addition, there is the possibility to build rooms as a mandatory element of a lecture series. Students will have to pass some of the rooms (e.g. a laboratory) on their way through a seminar before the successful completion of the lecture series is accepted.

Special function rooms like a room solely for teaching material or for a laboratory provide a clearly arranged structure of offered learning units in contrast to rooms containing all material of a complex lecture series. For example, a course consisting of a lecture, a seminar and a hands-on experiment can be distributed over three different rooms, which are presented in sequence or in parallel.

The function of a room will be constructed from three components as already mentioned above:

- room related rights
- specification of the room users
- used tools and communication interfaces

By assembling rooms with different functions in sequence or in parallel, a whole virtual university with lecture, seminar,

workshop or laboratory rooms with virtual and remote labs can be built up.

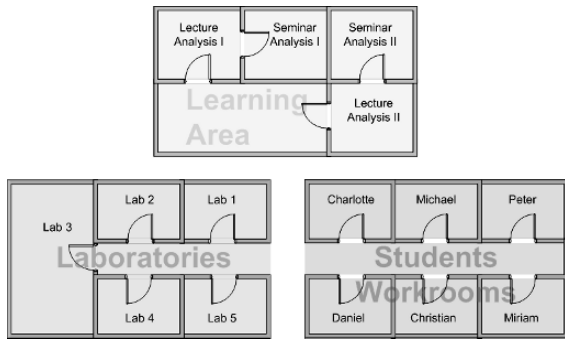


Fig. 1 Schematic presentation of different functional rooms

By this means, a user can be virtually supported in all phases of a course, scientists from different institutions and locations can discuss their research achievements and approaches or perform experiments in virtual and remote laboratories – all in one virtual building.

The “ViCToR-Spaces” room concept does not provide the rooms in a hierarchical structure as it is characteristic for currently deployed cooperative knowledge spaces ([5], [6]). We are not designing a static root-to-leaf structure but rather a dynamic, heterogeneous network, known in philosophy as a rhizome, such that each user will obtain a different view on the room structure of the system – according to the rooms which the user is interested in and related to.

The user can be assigned to certain rooms supporting their individual profile, e.g. to the rooms of a course the student is attending in this semester. Additionally, users can delete and add rooms constructing their individual network of rooms. The different perspectives of the users provide many different views on the room structure. The rooms define a new way of knowledge management.

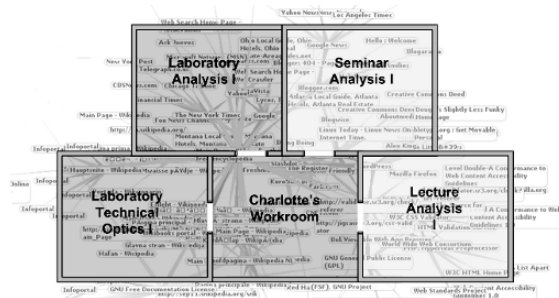


Fig. 2 Schematic presentation of the wikipedia network overlaid with the rhizome-like arrangement of the rooms from a user's perspective

III. THE ROOM COMPONENTS

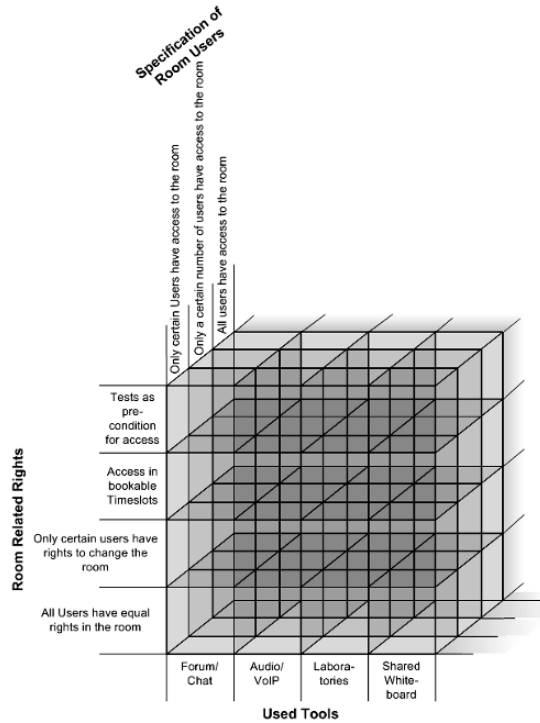


Fig. 3 Components of a functional room

A. Room Related Rights

Different from a physically existing room a virtual room can be built and completely deleted in short time. It is obvious, that not every user can be allowed to change or delete every room in the system. Room related rights are needed.

Room related rights have two different aspects. On the one hand, they refer to creating, deleting and changing a room. On the other hand, they define pre-conditions for the access to the room.

For rooms that can or should only be used by a limited number of users, the access can be controlled by bookable timeslots. Every user is assigned to limited time slots to accomplish a hands-on experiment in a laboratory.

As another pre-condition for the access to rooms a special test room can be added upstream such that the users first have to successfully complete the test before entering the next room. Following this principle, the serial operation of completing a test, booking a timeslot and finally accomplishing the hands-on experiment an artificial bottleneck is created. This is especially important in cases of

special laboratories where users need previous knowledge for accomplishing a certain experiment.

B. Specification of Room Users

In most “real life seminars”, three or four students form a work group to solve the tasks of the seminar together. In this case the room should “know” the identity of the group members to restrict the access to the room to this user group alone. All participants have equal rights in the room concerning the modification of the room. The users’ own work room would represent such a user-restrained room. Only the user himself can access his own work room.

There are also rooms that only should be accessed by a certain number of users e.g. in remote laboratories. In this case only the number of users who have access to the room is restrained without specifying certain users.

A third possible type of room user specification is the access to a room by all users.

C. Used Tools and Communication Interfaces

As a third function component the room can be previously filled with tools and communication interfaces, according to the room function.

Communication Interfaces are important elements in virtual, cooperative work. In our room concept we provide chats, discussion forums, email and a VoIP function. Not all interfaces need to be attached in all types of rooms. Small groups can manage a clear information exchange in a chat or VoIP session. In larger groups such communication sessions can get unmanageable. In exchange smaller groups might not require a discussion forum.

Shared Whiteboards provide a consolidated graphical work area for all room users. All participants are able to work with the same set of objects on the board. Similarly to a chat client the written and drawn objects are shown identically on all participants’ boards.

Shared Whiteboards can be used both in synchronous and asynchronous manner. Geographical and chronological distances are bridged with version-controlled sessions and documents. Scientists from Berlin and Shanghai can thus work cooperatively on scientific problems [4].

Virtual und Remote Labs are mainly used in education for engineering and natural sciences. These installations are an important issue for providing access to laboratory equipment independently from time or financial means.

Virtual labs are software simulations of real experiments or algorithms. Hence a user has a more precisely view on e.g. physical effects or machines. Also a virtual lab can demonstrate effects in a “purer” form, enhancing the results or eliminating interference that would “bury” the effect in a real experiment [3].

In contrast, remote laboratories are physically existing experiments that can be remotely controlled from any place in the world via internet.

In both laboratories parameters can be manipulated, controlled and read off. Different measurement instruments can be attached and combinations of virtual and remote labs for the same physical effect can exchange parameters and other information. In this way, output from a virtual experiment can be verified by the physically existing experiment.

IV. THE USER IN A VIRTUAL ROOM

The work of a user in a cooperative knowledge space is aligned with the “3C-model” (see [1]) - Communication, Coordination, Cooperation.

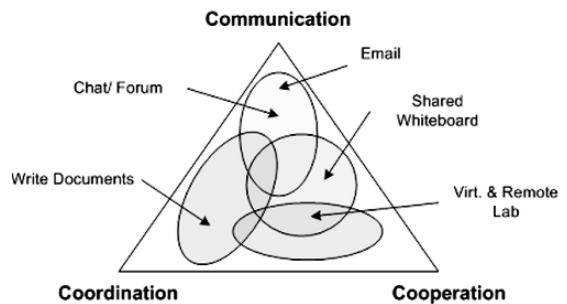


Fig. 4 The “3C-model”

Coordination: In virtual knowledge spaces a student can get support in all phases of scientific or educational work. Students can make appointments for joint work sessions or hands-on experiments. Also, lecturers and students can meet in project rooms to resolve questions etc. The coordination in virtual knowledge spaces also brings scientists from different institutions together and supports their work.

Communication interfaces are provided in multiple types. Students will mainly exchange information about a special lecture or difficult tasks. Lecturers will inform their students about news and the progress of a course and scientists will exchange research achievements or arising problems.

Cooperation constitutes the essential element of virtual knowledge spaces. Students and scientists cooperate in sessions of hands-on experiments. They describe mathematical problems on shared whiteboards and discuss about a physical algorithm over VoIP. In joint sessions they merge their knowledge and achieve high-grade research results. These achievements can be recorded in version-controlled documents if more than one session is needed.

The options of a user in a virtual knowledge space depend on the functionalities of the room. A group’s work room can

be equipped with chat, a discussion forum, VoIP function and a shared whiteboard so that the users in this room can choose the type of communication best suited to solving their tasks.

V. SAMPLE SCENARIO – ELEARNING

In this chapter we highlight the different aspects of the “ViCToR-Spaces” room concept in a sample scenario.

The scenario describes the work in a remote laboratory as a mandatory element of a lecture. Students need to jointly work on a hands-on experiment and save the data for later checking by the tutor.

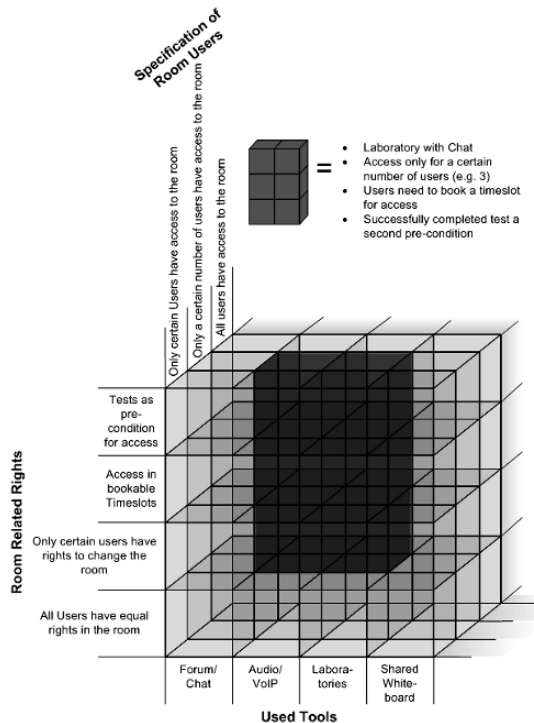


Fig. 5 The components of the sample room in scenario “eLearning”

The Room

The room will be built by a system administrator as a laboratory with restrained rights. The laboratory will hold the equipment for experiments from the field of optics where the measurement of the refraction index of different substances and objects is demanded.

The essential units of this hands-on task are the design and construction of this experiment and, afterwards, the performance of the measurements. First, the laboratory has to be constructed in the correct way; the correct in- and output values and measuring devices need to be attached. Afterwards, the required values need to be measured and saved.

For this experiment, the maximum number of users is restrained to three. The students have to book a timeslot and successfully complete a test as a pre-condition (e.g. a multiple choice test) for access to the lab. This combination of components for creating the respective sample room is seen in figure 5.

Interaction between the Users

All participants have the same view on the laboratory. First, they distribute the tasks and start constructing the laboratory. Of course, only one participant can manipulate a certain controller at a time, as in a real-world lab. Suppose, one participant can control parameter A and another participant controls parameter B, but one parameter can not be controlled by both participants at the same time.

They discuss the construction and measurements through VoIP or chat and complete the hands-on seminar jointly.

Completion and Data Storage

The experiment saves all interactions and measurements in a log-file. This log-file is only viewable for authorized persons like the admin and the tutor of the seminar. According to the log-file the tutor can decide whether the students successfully completed the seminar. The measurements are additionally stored in the students’ work rooms thus the results can be used for further experiments or tests.

VI. SAMPLE SCENARIO – ERESEARCH

As a second scenario we describe the work of scientists in a remote laboratory session. We categorize this scenario as eResearch as the scientists are researching a specific physical effect. In difference to experiments performed by students, the results of the experiment might either be known (thus serving as certification) or be completely new.

The Room

The room will be created by a system administrator as a laboratory room. The experiment is already physically set up and can be run immediately.

In this scenario the scientists work on a problem from the nanotechnology. Hence, the laboratory consists of a clean room with an AFM (atomic force microscope) and a mass spectrometer. There is also a shared whiteboard and the VoIP function activated.

Only four specific scientists have access to the room. They do not have to fulfill any pre-conditions like a test or booking timeslots. All scientists have equal rights in the room.

The function components for this sample room are pictured in figure 6.

In case the experiment does not lead to the expected results, the equipment can be changed, certain measuring devices can be attached or disconnected.

Interaction between the Users

The interaction between the scientists is analogous to the interaction between the students from the previous scenario. Only one user can manipulate the laboratory. The results are discussed over VoIP, with the whiteboard providing additional support for graphical representation of the ideas and concepts under discussion. Also, the shared whiteboard is used for the joint development of new theories and algorithms the scientists obtain while performing the experiment. The actual experimentation and the corresponding discussion on the whiteboard can be held asynchronously and are stored under version-control in the room.

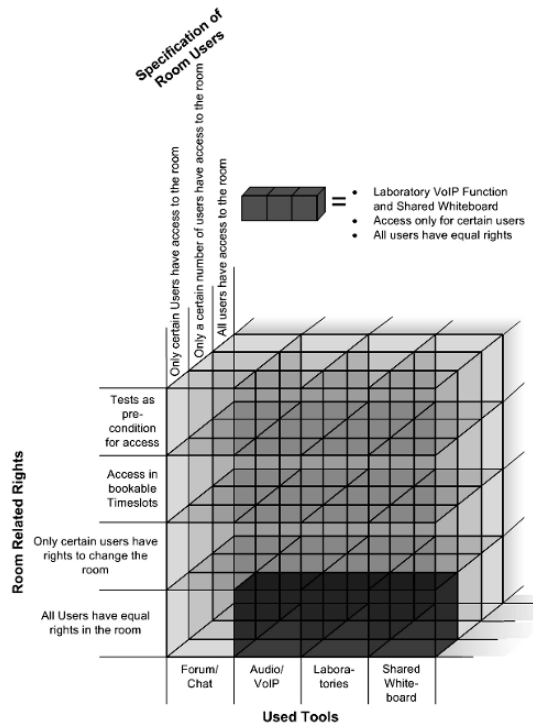


Fig. 6 The components of the sample room from scenario “eResearch”

Completion and Data Storage

As already mentioned the data will be stored under a version-control system. The results can also be stored in the scientists’ work rooms so they can be used in future measurements and experiments. Imported in a shared document the results can be used for a jointly written publication. Under version-control all participants of the experiment can bring in their experiences and knowledge in the paper.

VII. CONCLUSION AND OUTLOOK

The article describes a room concept in cooperative knowledge spaces to project scientific, cooperative work onto virtual rooms. We showed that knowledge spaces provide complex work areas for students and scientists independently from location and time. Room concepts for different scenarios from educational and scientific work are provided and the substantial aspects and components of building virtual, cooperative rooms are described.

For the realization of the concepts we use a system already deployed (CURE, see [3]) and expand it with the respective components. Some of the components are already implemented. They will be expanded to provide comprehensive metadata are to be integrated into CURE using web technologies like Web Services and a semantic ontology. Furthermore, we will integrate concepts of game-based learning. Thereby, we create a complex community-based learning and research system that forms a virtual reflection of “real world” work avoiding its drawbacks and enforcing its assets.

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Comparative study of learning achievement on the online asynchronous learning course in engineering metallurgy between individual-learning and group-learning

Santirat Nansaarn

Department of Production Technology Education
King Mongkut's University of Technology Thonburi
Bangkok, Thailand
santirat.nan@kmutt.ac.th

Supreeya Siripattanakunjorn

School of Education Studies
Sukhothai Thammathirat Open University
Nonthaburi, Thailand
edasssup@stou.ac.th

Abstract—In this study, authors describe the construction of Interactive Multimedia Computer Instruction Package (IMMCIP) on web for online asynchronous learning on engineering metallurgy course. The efficiency evaluation and comparative study of the learning were achieved between individual learning and group learning. The research tools were constructed an IMMCIP on Web, which included introduction to engineering metallurgy, crystal structure, deformation mechanism, phase diagram, Fe_3C -diagram, heat treatment process, ferrous metals, non-ferrous metals, corrosion in metals and powder metallurgy. The samples were 30 undergraduate students in engineering metallurgy course in Department of Production Technology Education, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Thailand. The samples were divided into three groups: one computer per student, one computer per two students, and one computer per three students, which are 11, 10 and 9 students respectively. The results revealed that the efficiency of an IMMCIP on Web was higher than that the criteria set. Results were analyzed on pre-test and post-test of every group, which were achieved significantly high score. The results found that learning achievement of one computer per three-student group was different from others and had the higher learning achievement with significantly.

of classrooms and the need was not last for an hour. The internet revolution enriches learning with mass customization, collaborative filtering and object orientation, production on the fly, easy-to-use authoring software, cheap video, rapid application development, plug-and-play modularity, wireless connectivity, abundant bandwidth, and more. [2]

Engineering Metallurgy is one of several subjects in undergraduate of Bachelor degree of Industrial Education in Production Technology Education Department. In order to succeed in this subject, it is important to increase the knowledge of metallurgy theory and practices, e.g. principle of atomic, heat treatment process or phase transforms mechanism. However, online asynchronous learning is alternate learning for helping student to better understand in this course. Because it was combination between Internet technology and learning design process in order to increase learning efficiency and improve limitations, such as learning site or time, the use of Internet resource and properties to encourage and facilitate education is important [3]. Therefore, we interested studying about the best student's learning method by via the independent which were online Asynchronous learning with individual learning and collaborative-learning or group-learning to compared the learning achievement on both of them and took the results of this research using in engineering

I. INTRODUCTION

Online learning is in its infancy. As pioneers struggle with new technologies and practices, the discipline evolves almost daily [1]. Yet despite the rapid change, trends may be identified, which points to the future of online learning. This is not radically different from current models but it may be conceived, however, some significant shifts in the nature of online learning, and learning in general.

By 2002, people would be free of the obsolete inefficient model of learning imprinted by the school system. Real learning was started by learner. People learn it by solving several problems, making mistakes and correcting them, hearing stories, engaging multiple senses, and following the call of their innate curiosity. Learning could take place outside

Objectives

The objectives of this research were:

- 1) To construct of Interactive Multimedia Computer Instruction Package (IMMCIP) on web for Online Asynchronous Learning (OAL) in engineering metallurgy course;
- 2) To evaluate the efficiency of IMMCIP on web for Online Asynchronous Learning for distant learning;
- 3) To compare the learning achievement between individual and group learning.

Expected Benefits

- 1) To obtain knowledge of principle and application in engineering metallurgy;
- 2) To obtain IMMICIP on web for Online Asynchronous Learning for engineering metallurgy;
- 3) To learn how to produce IMMICIP on web for Online Asynchronous Learning and apply for developing other courses;
- 4) To promote knowledge of engineering metallurgy and community.

II. RESEARCH METHODOLOGY

A. Scope of research

The contents of this IMMICIP on web were consisted of ten topics as followed: introduction to engineering metallurgy, crystal structure, deformation mechanism, phase diagram, Fe₃C-diagram, heat treatment process, ferrous metals, non-ferrous metals, and corrosion in metals and powder metallurgy

B. Population and Samples

The population of this research was students enrolled in the Bachelor degree in Production Engineering at King Mongkut's University of Technology Thonburi (KMUTT), Bangkok, Thailand, as well as related persons who are interested.

The samples of this research were 30 students, who were selected randomly. Then, they were divided into three groups of 11, 10 and 9 students per group.

C. Experimental Tools

The IMMICIP on web for Online Asynchronous Learning for engineering metallurgy was designed and developed utilizing an Interactive Multimedia Computer Instruction Package (IMMCIP) (Fig. 1) [4]. The IMMICIP on web for OAL was constructed in terms of modules and present in website form (Fig. 2). The flow chart of this course was presented in Fig. 3

The procedure of this research was organized in IMMICIP concept in five steps as shown in Fig.1. This process was classified as followed:

i. Analysis

- 1) Brainstorm chart drafting;
- 2) Concept chart drafting;
- 3) Contents network analysis chart drafting;

ii. Design

- 4) Strategic presentation plan with behavior objectives and course flow chart drafting;

5) Module presentation chart drafting;

iii. Develop (Course Forming)

- 6) Script development (Interactive subject frames);

- 7) Story development by storyboard technique;

- 8) Contents correctness, contents validity and reliability check-up;

- 9) Test item check-up (Difficulties, discrimination, validity and reliability);

iv. Implementation

- 10) Authoring software selection (This research is meaning in order of Web Based Programming and Database, e.g. PHP, ASP, SQL, MySQL);

- 11) Acquisition of readymade or tailor-made video, animation, audio, picture and other clip arts;

- 12) Completion of creating IMMIP (This research was created in WBI from);

v. Evaluation

- 13) Quality evaluation (Multimedia and instruction design check-up);

- 14) Small group rehearsal testing;

- 15) Efficiency evaluation (E_1/E_2) effectiveness evaluation ($E_{\text{post-test}}/E_{\text{pre-test}}$);

- 16) Preparation of user's manual for publication

A content of evaluation specialist reviewed for the test's content validity. The test items were analyzed (easy or difficult), which was in the range of 0.20-0.80. The acceptable reliability value has to be more than 0.20, which was based on Kuder-Richardson 20's formula, and should not be lower than 0.60.

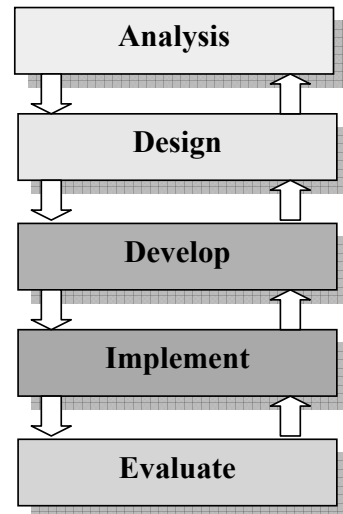


Fig. 1. Structure of the Interactive Multimedia Computer Instruction Package (IMMCIP)

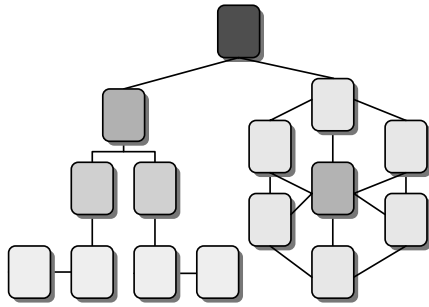


Fig. 2. Example of lessons modules

TABLE I.
TOPICS AND CONTENTS OF THE HOMEPAGE .

Unit	Topics	Contents
1	Introduction to engineering metallurgy	Text Picture
2	Crystal structure	Text Picture Animation
3	Deformation mechanism	Text Picture Animation
4	Phase diagram	Text Picture Animation
5	Fe ₃ C-diagram	Text Picture Animation
6	Heat treatment process	Text Picture Animation
7	Ferrous metals	Text Picture Animation
8	Non-ferrous metals	Text Picture Animation
9	Corrosion in metals	Text Picture Animation
10	Powder metallurgy	Text Picture Animation

These modules along with the tests were tried out. The experiment was then conducted to determine its efficiency.

The samples were divided into three groups. The first group was studied on one computer per student. The second group was studied on one computer per two students. The last group was studied on one computer per three students.

The test was started with the sample group amount 30 students to finding the lesson efficiency, and the criterion was set at 80/80. After that, the next step was the test of learning achievement on three sample groups. Finally, data was collected and analyzed by T-Test and ANOVA.

D. Research results

The construction of the Web-based instruction for Online Asynchronous Learning for engineering metallurgy could be summarized as follows:

1) The contents of IMMCIP on web for OAL have ten topics and each topic could be explained the contents of the unit topics in Table I and Fig.4

2) Results of the IMMCIP on web for OAL efficiency were shown that during learning process the percentage of total average score of efficiency was 88.92 (module test), but the total average score after learning process was 87.75 (post test). Therefore, the efficiency of the IMMCIP on web for OAL was 88.92/87.75 shown in Table II, which is higher than the criteria set at 80/80.

TABLE II.
AVERAGE SCORE OF MODULE AND POST TEST.

Module test score	Post test score
88.92	87.75

TABLE III.
T-TEST OF PRE-TEST AND POST-TEST SCORES OF EACH GROUP.

Group	n	Pre-test		Post-test		T-test
		\bar{X}	SD	\bar{X}	SD	
1:1	11	26.73	4.29	84.27	10.24	21.911*
1:2	10	33.00	6.05	85.50	7.55	13.464*
1:3	9	42.33	8.76	95.22	4.27	28.221*

*P<0.05

TABLE IV.
ANALYSIS OF VARIANCE (ANOVA) OF GAIN SCORES.

Source of Variance	Sum of Squares	df	Mean Square	F	P-value.
Between Groups	109.25	2	54.62	5.35	.011
Within Groups	275.44	27	10.20		
Total	384.70	29			

*P<0.05

3) The results of the finding learning achievement test with three sample groups appeared that they had the higher learning achievement significantly (see Table III and Fig. 5) by using T-Test. Then, the ANOVA was analyzed and found that three sample groups had the significantly different achievements. When a pair of groups was compared between both tests, it appeared that group one computer per one student, group one computer per three students, group one computer per two students, group one computer per three students and group one computer per three students, one computer per two students were shown significantly different, which considered from the average score in Table IV. This could be known that the learning achievement of one computer per three students would provide the higher achievement significantly. The second was one computer per two students. The last was one computer per three students.

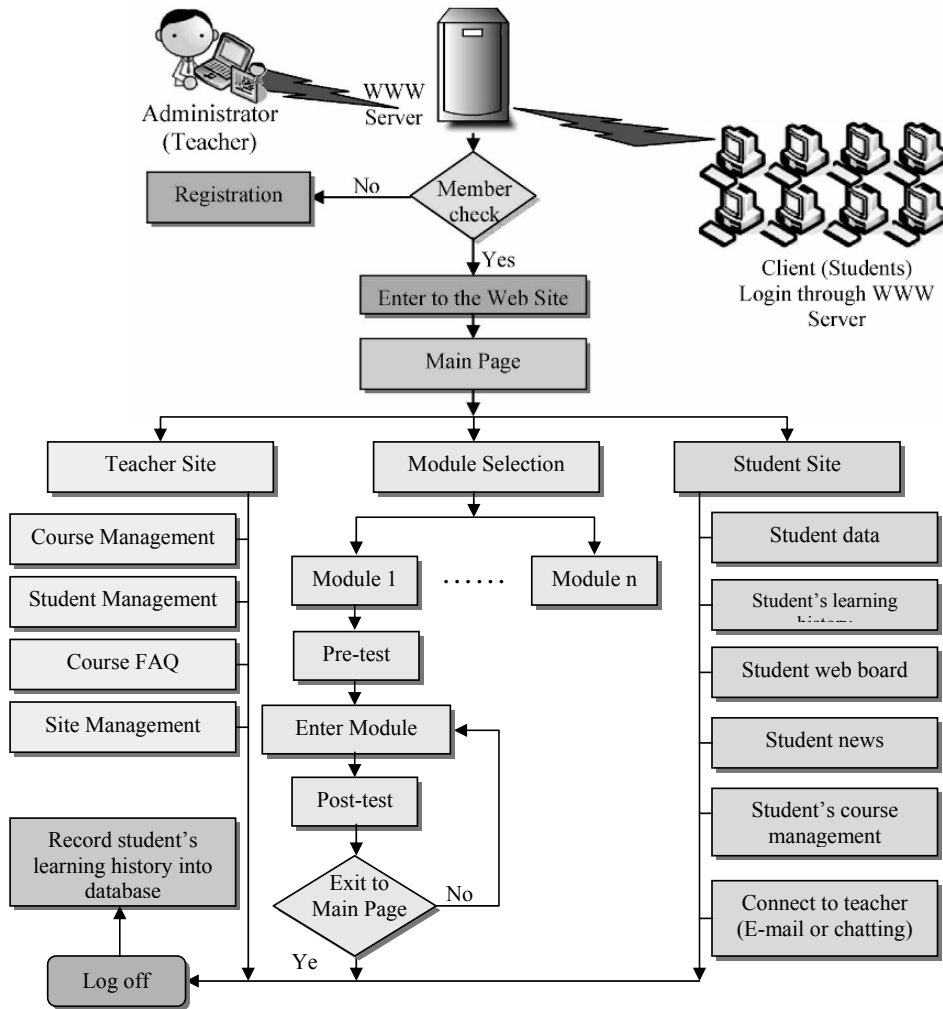


Fig. 3. The IMMCIIP on web for Online Asynchronous Learning Structure

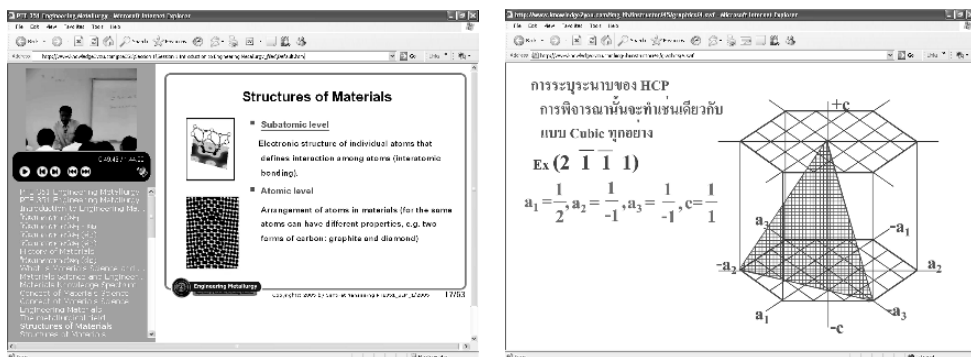


Fig. 4. Samples of Interactive Multimedia Computer Instruction Package (IMMCIIP) on web for OAL

TABLE V.
LSD OF THE GAIN SCORES.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval	
					Lower Bound	Upper Bound
1:1	1:2	-.46364	1.39556	.742	-3.3271	2.3998
	1:3	-4.36364(*)	1.43560	.005	-7.3092	-1.4180
1:2	1:1	.46364	1.39556	.742	-2.3998	3.3271
	1:3	-3.90000(*)	1.46755	.013	-6.9112	-.8888
1:3	1:1	4.36364(*)	1.43560	.005	1.4180	7.3092
	1:2	3.90000(*)	1.46755	.013	.8888	6.9112

* P<0.05

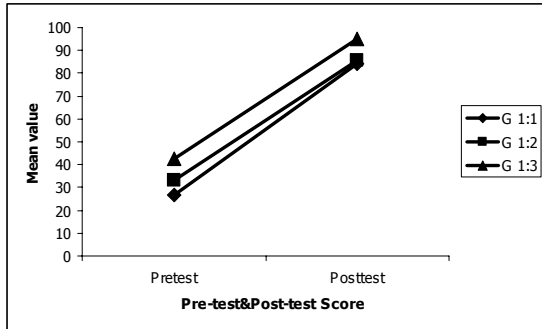


Fig. 5. Pre-test and Post-test scores of three groups.

E. Conclusion

Researchers constructed an Interactive Multimedia Computer Instruction Package (IMMCIP) on web for Online Asynchronous Learning for engineering metallurgy. The contents of the IMMCIP on web for OAL were consisted of 10 modules. Each module has 4 sections including pretest, module contents, exercise and post-test. Moreover, the package was composed of learning management system such as registration, student's database, and achievement evaluation for each module. For pretest and posttest, and module test, questions were selected randomly and evaluation was done according to the objectives of each module. The evaluation result of each module was also informed to subjects. The result of the experimental was showed that the efficiency of package was 88.92/87.75. It cloud be conclude that the efficiency of the package was higher than the standard set at 80/80. According to the comparison of leaning types on three sample groups, it was found that collaborative learning or group learning was the learning method, which could increase the higher learning achievement than individual learning by adding the student's cognitive upper cause. It was integration learning and shared

knowledge to each others [5, 6]. Furthermore, group learning was the method, which could be used as discussing and increasing knowledge on providing their opinions and co-operated decisions efficiency [7]. While cooperative learning provides several benefits for students in academic achievement, self-esteem, active learning, social skill development, and equity achievement are still important [8, 9, 10, 11]. Therefore, it could be summarized that learning via Interactive Multimedia Computer Instruction Package (IMMCIP) on web for Online Asynchronous Learning (OAL) on group learning could increase learning achievement better than individual learning.

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An Architecture for a SCORM-Conformant Content Delivery System in an E-learning Solution

Sedigheh Abbasi, Gholamhossein Dastghaibiyfar
Department of Computer Science and Engineering, College of Engineering,
Shiraz University, Shiraz, Iran

Abstract - This paper proposes an architecture for a SCORM (Sharable Content Object Reference Model)-conformant content delivery system in an e-learning solution. Since the most important purpose of e-learning technology is to deliver highest quality education and training cost-effectively anytime and anywhere, in this paper we focus on learning content delivery as an online and asynchronous manner. On the other hand, in order to build an interoperable system, it is clear that we should utilize e-learning standards and specifications. For this reason, various available solutions have been evaluated and it has been found out that SCORM, as a comprehensive collection of e-learning specifications and standards, has some unique features which are useful specially for employing in a content delivery system. Eventually, we turn to the implementation perspective of our proposal. In particular, what is important to this study is that how an LMS (Learning Management System) employs the sequencing strategy defined by content author to deliver the appropriate piece of content at any given time and how to pave the way for communicating with content object at run time based on SCORM criteria in order to make proper decisions about delivery of next content object to the learner.

I. INTRODUCTION

Just as the Web became popular, it has been found out that has deep potential for efficient distributed learning. Web-based learning can be divided in two categories: “online synchronous” and “online asynchronous.” Online synchronous learning requires video and audio conferencing tools as well as other requirements of a virtual classroom which is outside the scope of this paper. Whereas, in online asynchronous learning we should create individual learning objects and organize them as packed content via an authoring tool and then deliver the authored content to learner using internet as main medium. Therefore, two major components of an online asynchronous e-learning solution are content authoring tool and content delivery tool. Besides these components, an assessment tool is also needed for creating tests, quizzes and self exams which are special types of content objects and can be considered as a part of content authoring tool.

As mentioned earlier, content authoring tools help the instructor to create and organize learning objects. The organization of content objects consists of identifying the logical relationship of included content objects as well as defining the sequencing rules between learning contents and specifying the presentation options. In this way, an efficient

content delivery tool should be able to provide the learner accessing the authored learning contents and consider with respect to defined sequencing rules to deliver the correct content objects at any given time and keep track of learner interactions with the content in order to make proper sequencing decisions.

This paper mainly focuses on various aspects of a content delivery system in an asynchronous e-learning solution. In this connection, section II deals with the importance of e-learning standards and specifications, in section III SCORM (Sharable Content Object Reference Model) will be considered at a glance and the reasons of employing it will be given. Our proposal for the architecture of a SCORM-conformant content delivery system will be explained in section IV and finally the implementation issues of our proposed architecture will be perused in section V.

II. ROLE OF E-LEARNING STANDARDS

Essentially, many content providers know that without a pervasive set of e-learning specifications and standards, they would have to keep converting their contents in order to suit the particular e-learning environment of the learner. Therein lies the first issue - interoperability of the e-learning content [9]. In other words, interoperability among e-learning content and system components is a key to the successful implementation of an e-learning solution. From a learning content producer’s perspective, standards allow content to be produced in a single format for use by any delivery system [8].

Since the beginning of 2001, several notable learning resource specifications have gradually become mature after many years’ efforts, which provide us with new opportunities to construct reusable and interoperable LMS (Learning Management System) and further exchange “standardized” learning resources between these LMSs [7]. Among the all principal learning resource specifications, SCORM, as a foundation for accomplishing the goals of ADL (Advanced Distributed Learning) initiative, has special features which arouse our interest. As a matter of fact, SCORM references specifications, standards and guidelines developed by other organizations and adapted and integrated with one another to form a more complete and easier-to-implement model [4]. SCORM smartly references IMS (Instructional Management System) and LOM (Learning Object Metadata) as well as other

specifications to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content. On the other hand, SCORM has also a feature which makes it unique. It provides an RTE (Run-Time Environment) which covers the essential responsibilities of a content delivery system for managing content objects during run time and providing infrastructure for interoperability between content objects and LMSs.

Overall, SCORM has deep potential for using it as the foundation of a content delivery system. Hence, a brief explanation of it has been given in the next section.

III. SCORM OVERVIEW

In the early days of WBI (Web-Based Instruction) an unstructured presentation or a heap was the dominant form of content presentation for Web courses. A heap is essentially an assorted set of static HTML (HyperText Markup Language) pages connected to the course home page [6]. Nowadays, an ability to support structured presentation is a base level requirement. For this reason SCORM uses a structured map of learning resources or a structured activity map to guide the learner through a hierarchy of learning activities that use the learning resources. This structured map is called *Content Organization*. In the latest version of SCORM (ver. 1.3/2004), the Content Organization not only can be used as a kind of table of contents for the related resources, but also is used as a way to describe the hierarchy of learning activities that exploit the learning resources [3].

Once learning content is designed and built, there is a need to make the content available to learners, authoring tools, repositories or LMS's. On the other hand, adopting Content Packages provide a standardized way to exchange digital learning resources among systems. For this reason, the IMS Content Packaging Specification was designed to provide a standard way to structure and exchange learning content [3]. A *Content Package* consists of physical resources related to the content as well as the organization of content and physical file references that are described in an XML (eXtensible Markup Language) document. Content providers can use Content Packages to construct reusable and sharable learning resources. SCORM extends IMS Content Packaging Specification by providing additional requirements and implementation guidance for packaging the Assets, SCOs (Sharable Content Objects) and Content Organization. The SCORM CAM (Content Aggregation Model) describes responsibilities and requirements for building content and Content Organizations (e.g. course, lessons, modules, etc). This model also contains information on creating Content Packages, applying meta-data to the components in the Content Package and applying sequencing and navigation details in the context of a Content Package [3].

From the SCORM perspective, there are three types of learning objects: *Assets*, *SCOs* and *Content Organization*. Content Organization, which has been explained earlier, is a nonlaunchable learning object, while Assets and SCOs are known as launchable learning objects. A launchable learning

object can be delivered to the learner's Web browser via HTTP (HyperText Transfer Protocol).

Theoretically, Asset is the most basic form of a learning resource which can be defined as an electronic representation of media, such as text, images, sound, assessment objects or any other piece of data that can be rendered by a Web client and presented to a learner. On the other hand, a SCO is a collection of one or more Assets that represent a single launchable learning resource that utilizes the SCORM RTE to communicate with LMSs. In other words, a SCO represents the lowest level of granularity of a learning resource that is tracked by an LMS using the SCORM RTE [3]. Therefore, the only difference between an Asset and a SCO is that a SCO requires communicating with LMS at run time and an Asset doesn't.

According to above considerations, we will propose a general architecture for an SCORM-conformant content delivery system.

IV. SCORM-CONFORMANT CONTENT DELIVERY ARCHITECTURE

As explained in previous section, SCORM describes a CAM and an RTE for learning objects to support adaptive instruction based on learner objectives, preferences, performance and other factors (like instructional techniques) [4]. Although one of the elementary requirements of a SCORM-conformant content delivery system is to adhere to CAM specification, handling the learner interaction with the learning content at run time is also an essential functionality which is the main idea of SCORM RTE.

For this reason, we propose an architecture for a SCORM-conformant content delivery system which covers main requirements of such a system. Our proposal is a multi-service architecture which contains four basic components:

- *Sequencing Service*
- *Delivery Service*
- *Tracking Service*
- *API (Application Programming Interface) Instance*

Fig.1, mainly represents these components and their relationship with each other.

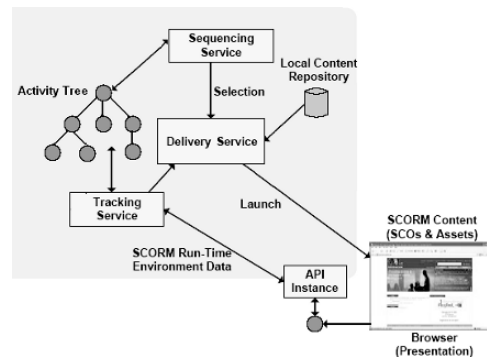


Fig.1. Content Delivery System Architecture.

In the following sections, we will give a brief specification of an Activity Tree and then the role of each component will be explained.

A. Activity Tree

SCORM defines and utilizes Activity Tree concept in order to describe the structure of learning activities as well as informational and processing requirements of SCORM Sequencing and Navigation Model such as sequencing algorithms and behaviors in an implementation independent manner. In fact, an Activity Tree represents the data structure that a SCORM-conformant content delivery system implements to reflect the hierarchical and internal representation of the defined learning activities, including the tracking status information for each activity in the hierarchy [2].

B. Sequencing Service

One of the most important complications of implementing a SCORM-conformant content delivery system is to apply the authored sequencing and navigation rules defined in the package manifest, in order to identify proper content object for delivering at any given time.

In this way, Sequencing Service is part of the content delivery system which is responsible for keep tracking of sequencing strategy defined in Content Organization. Using the Activity Tree concept, Sequencing Service will be able to choose proper learning activity for delivering to the learner with respect to defined sequencing strategy. In other word, Sequencing Service is known as part of content delivery system which is triggered whenever a learner- or system-initiated navigation request occurs.

C. Delivery Service

When a content object has been selected for delivering, it is the responsibility of Delivery Service to launch it based on its type (Asset or SCO) in the learner's Web browser. For this reason, this component should be closely related to Sequencing Service. Also, in order to have an interoperable system, Delivery Service should utilize SCORM RTE recommendations associated with launching content objects.

D. Tracking Service and API Instance

Tracking Service is another essential component which enables content delivery system to track learner progress and performance while content is presented to the learner. For this reason there should be some ways to manage the learner interactions with presented content object at run time. For this to be possible content delivery system uses an API Instance to establish communication with launched content object and gather information about learner interactions with content object. In fact, the API instance represents the piece of executing software that the SCO interacts with during the SCOs operation [1]. In this way Tracking Service can use gathered information for learner tracking. On the other hand, it may be

necessary for Tracking Service to update the Activity Tree based on learner's tracking information.

V. IMPLEMENTATION ISSUES

In order to implement an SCORM-conformant content delivery system, it is necessary to implement each of components in proposed architecture and support the relationship between them.

As mentioned earlier, in order to response to a delivery request, we should be able to identify the appropriate content object to launch according to the sequencing strategy defined in the Content Organization. On the other hand, SCORM CAM specifies that all of information about logical structure of learning activities and underlying sequencing strategy and references to physical resources of content should be placed in a special XML file named *imsmanifest*.

Therefore the first step for enabling Sequencing Service to do its responsibility is to derive and implement the Activity Tree from *imsmanifest.xml* file. For this to be possible we should use an API for XML processing. On the other hand, XML enables "portable data" and it can be quite powerful when combined with the "portable code" enabled by Java [5]. So, we can use JAXP (Java API for XML Processing) for processing *imsmanifest.xml* file into Java objects for deriving the Activity Tree. JAXP provides basic support for parsing and transforming XML documents through a standardized set of Java platform APIs.

In addition, the implementation of the Activity Tree can be done by defining a Java class which encapsulates all of the required information for processing by Sequencing Service.

SCORM specifies three types of Data Model which Sequencing Service utilizes information from all three models. These Data Models are [2]:

- *Tracking Model* which is a dynamic run time data model that captures information gathered from the learner's interaction with the content objects associated with activities.
- *Activity State Model* which is a dynamic run time data model utilized by the LMS's Sequencing Service to manage the sequencing state of each activity in the Activity Tree and the global state of the Activity Tree.
- *Sequencing Definition Model* which is a static data model (defined in a SCORM Content Package) describing authored sequencing intentions for a given Content Organization.

The Sequencing Service itself can be implemented using Java technology too. In other word, several sequencing processes can be encapsulated as a Java class.

Implementation of Delivery Service can be done using JSP (JavaServer Pages) technology. JSP is based on Java language and allows server side Web programming. With the use of JSP, accessing the physical resource associated with identified content object for delivery and launching it in learner's Web browser can be possible.

API Instance and Tracking Service are closely related to SCORM RTE implementation. The SCORM RTE implementation requires both client side and server side

programming. On the client side, a Java Applet object is required to manage the learner interactions with the launched content object (SCO). In fact, this Java Applet is the implementation of the API Instance. On the other hand, as discussed earlier the API Instance should communicate with Tracking Service component. This component does its responsibilities at server side. Therefore, we can implement it as a Java Servlet object which communicates with client side (API Instance) at run time and ensures the persistence of any communicated data.

CONCLUSION

In this paper we proposed a general architecture for a SCORM-conformant content delivery system. We also focused on the implementation aspect of such a content delivery system in detail. In this direction, we have employed our proposal in implementation of an actual content delivery system and obtained results show that this architecture is quite useful.

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Impact of University Education on Software Quality Skill-set of HR in Software Outsourcing Industry of Pakistan

Muhammad Emad-ud-din

Shahid Javed Ansari

Center for Advanced Studies in Engineering (CASE)

19 Ataturk Ave. G 5/1 Islamabad, Pakistan

emaduddi@usc.edu

I. INTRODUCTION

Abstract - The authors of this paper have attempted to suggest an ideal set of software quality skills for IT Outsourcing companies that could boost software export revenues of software export-focused IT firms in Pakistan by enhancing much needed quality factor in their products and services. This ideal set of skills is extracted by assessing the quality related human resource from top performing IT outsourcing companies in Pakistan. In order to identify quality skills that are not imparted to IT professionals with adequate emphasis, a curricula based analysis of software quality related programs in top Pakistani IT universities was done. As a result of this analysis, again a set of imparted software quality skills at top Pakistani universities was identified. Authors believe that skills that are not addressed either at university end or IT company's end, can be incorporated in curriculum of software related courses offered at Pakistani IT universities. This step would result in enrichment of local IT resource which without requisite quality skills has to rely solely on expensive foreign quality certifications. The authors' research is based on two basic but crucial assumptions (i) an IT professional who gained software quality skills through his/her university education years has a significant positive impact on quality of software produced by his organization (ii) Most software-exporting companies outperform others due to their emphasis on software quality. No previous studies done locally, have been able to establish a clear relation between demand of industrial software quality skills and requisite supply of skills from universities.

It is beyond doubt that Pakistani software-export industry apart from a hand full of successful companies has not been able to exploit its true potential in terms of availability of non-expensive human resource. Among several other reasons responsible for this inability one major reason is the lack of quality practices that need to be followed at country's software houses [1] [2]. Despite factors such as negative image portrayal through media that contribute in repelling foreign companies from investing in Pakistan, an already large presence of foreign firms in Pakistan [2] brings to notice an important observation i.e. successful multinational firms bring with them a well matured model of quality assurance yet gaps are still evident in quality sector of many local setups of multinationals. Question arises, why? The authors believe that at whatever maturity stage any model of quality assurance be, it is rendered inefficient if human resource deployed on such models lack requisite quality skills. Unfortunately IT human resource in Pakistan lacks much needed software quality skills and this research attempts to identify same skills. The research effort in this paper involves gathering a snap-shot of profiles held by Quality Assurance (QA) teams/departments at top eight performing software export-oriented IT firms in Pakistan [3]. From these profiles, a skill set can then be formulated that represents the types of skills top performing Pakistani IT firms employ to achieve high sales and revenue. Finally the successful-companies skill-set is compared with skill set provided by top Pakistani IT universities and deficient software quality skills in our university curricula and IT industry are identified. It should be noted here that all universities assessed have either graduate or undergraduate level programs

Companies -->	Netsol	Ovex Tech	Descon	ITIM	TPS Pakistan	Systems Intl	Kalsoft	Etilize
Skills								
A. Understanding of software quality & models	X	X	X	X	X		X	X
B. Software quality goals & objectives								
C. Quality Mgmt systems documentation								
D. Problem reporting & corrective actions								
E. Audits	X					X		
F. Life cycle methods	X	X	X	X	X		X	X
G. Requirement management			X					X
H. Planning			X			X		
I. Tracking & control			X					X
J. Metric & measurement theory	X	X	X	X	X	X	X	X
K. Verification & validation planning	X	X	X	X	X	X	X	X
L. Peer reviews	X	X	X	X	X			X
M. Testing	X	X	X	X	X	X	X	
N. Configuration Management	X	X	X	X	X	X	X	X
O. Basic Statistics Methods	X	X	X	X	X	X	X	

TABLE I

offered related to software quality. Profile various QA departments/teams includes programmer to Project Manager (PM) ratio, ratio of QA employees to total employees, certifications, trainings and degrees held by QA employees.

II. SNAP-SHOT OF PROFILES HELD BY QA TEAMS/DEPARTMENTS AT TOP EIGHT PERFORMING IT FIRMS

Since Software export bears the advantage of having high revenues and well documented generic market requirements [1] more and more investors are cashing the opportunity that relatively predictable market scenario has to offer them. This trend is depicted by marked increase in IT export revenues since 2002 [2]. It is obvious that under such scenario where each IT outsourcing based company would be competing for projects based on its bid for high quality end-product, each company is struggling to acquire adequate software quality expertise available to its projects. Authors believe that major sources of such expertise are (i) skilled professionals produced by local universities (ii) foreign university qualified and certified professionals. To cater for demand of expertise in IT companies, local universities contribute 88%, foreign universities and certifications 9% of the total expertise hiring [4], thus leaving us with local universities as the major source of

imparting software quality expertise. Authors gathered profile details from top eight performing IT outsourcing companies' QA teams and departments. Authors then tabulated software quality skills gained by employees of each department/team by mapping their certification, trainings and university degrees to a set of 15 standard quality skills provided by American Society for Quality (ASQ) [6]. Concerned tabulated matrix is shown as Table 1 for reference.

III. SOFTWARE QUALITY RELATED SKILL-SET IMPARTED BY TOP IT UNIVERSITIES IN PAKISTAN

One can understand that it is beneficial to learn software development and quality skills at undergrad/graduate level because of the lack of time one finds to learn these skills after joining industry [7]. In this regard authors explored software quality related graduate and undergraduate level programs for 15 standard software quality skills as identified by ASQ [6]. Course outlines from offered programs were scrutinized to identify above-said skill-set. Another mapped matrix was created showing various software quality skills mapped to top IT universities. The mapped matrix table is shown as Table 2 for reference.

Universities -->	GIKI	FAST	LUMS	NUST	CASE	FOUNDATION UNIV	ISLAMIC UNIV
Skills							
A. Understanding of Software Quality & Models	X	X	X	X	X	X	
B. Software Quality goals & objectives							
C. Quality Mgmt systems documentation							
D. Problem Reporting & corrective actions							
E. Audits							
F. Life cycle methods		X	X	X		X	X
G. Requirement management					X	X	X
H. Planning					X		
I. Tracking & Control					X		
J. Metric & Measurement Theory	X	X	X		X		
K. Verification & Validation Planning	X	X	X	X	X		
L. Peer reviews	X	X					
M. Testing	X	X	X	X	X	X	
N. Configuration Mgmt		X	X		X	X	
O. Basic Statistics Methods		X	X		X	X	X

TABLE II.

IV. COMPARISON & ANALYSIS OF COLLECTED DATA

The reason for choosing best performing IT outsourcing firms and top IT universities for software quality skill-set assessment was to be able to (i) show a gap between the skills demand and supply (ii) keep other variables such as university performance and company performance at optimistic values in order to represent best possible skill-set snap-shot (iii) ensure that skill situation is the only remaining factor that controls change in the behavior of our data. The authors calculated number of IT outsourcing companies employing a particular skill for each of 15 skills from ASQ and plotted the results on graph. Similarly number of IT universities offering a particular skill were calculated for each skill and subsequently plotted on a graph. A skill situation snap-shot emerged when plotted points were joined as an area chart. This snap-shot described which skills are emphasized and which skills are ignored by top performing companies and to what extent. Resultant chart is shown in figure 2 for consideration.

A. Findings from Data: Figure 2. reveals that 15 generic software quality skills mapped to the skills available from universities and those deployed in software industry follow almost the same curve (of course with different magnitudes). Following findings explain the

existence of pattern in Figure 2. (i) Top-performing IT outsourcing companies' quality skills demand is catered for by software quality related courses offered by curricula of top IT universities. (ii) Top-performing IT outsourcing companies hire their quality workforce from top IT universities. (iii) Top performing companies prefer hiring workforce from top IT universities as software quality skills imparted by such universities cause to boost their revenues. Besides these findings provided skill snap-shot presents formula for quality that top Pakistani IT-outsourcing firms use in hiring their human resource. Another interesting observation the snap-shot suggests is that apart from one self-acquired skill i.e. "Audits", rest of the skills employed by IT companies are offered by top universities' curricula.

B. Deductions: Findings given in previous section if considered in an overall IT industry perspective, suggest following facts. (i) IT universities are the primary source of software quality skills in Pakistan as software quality related certifications are expensive and not available locally. (ii) Very few certified professionals are available in local IT industry for on-job trainings [4]. (iii) Even top performing IT outsourcing companies are facing crises situation in terms of availability of software quality skills [1], as indicated by Figure 2. Skills B, C, D are non-existent among top-performers. Deficiency of these skills might explain low



Figure 2. Software quality skills snap-shot

revenue performance of Pakistani outsourcing industry [1][2]. (iv) It is not necessary that offered quality skills at top universities are also satisfactorily imparted to their students. (v) Skills B, C, D and E must be included at least in MS software engineering programs in local IT universities in order to attract outsourcing business at a larger scale. Other skills which are offered in very few top universities i.e. skills G, H, I, J, K and L must be offered at other universities.

V. CONCLUSION AND SUGGESTIONS

Authors main claim in their research is that as a present day strategy low performing IT outsourcing companies can deploy software quality skill function presented in figure 2, in their hiring practices for better quality end-products. Going further in future authors suggest that deficient skills i.e. B,C and D must be introduced in local university curricula as no major supplying source for these skills exist locally i.e. quality certifications. Authors also suggest enhancement of qualifications of local faculty in terms of software quality skills. Bringing in vendors for software quality tools and starting internationally recognized software quality certifications locally would improve the presently grim situation of software quality skills.

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State Model Diagrams – a Systems Tool for Teaching Network Technologies and Network Management

S. P. Maj, B. Tran, D. Veal
School of Computer and Information Science
Edith Cowan University

2 Bradford Street, Mount Lawley, 6050, Western Australia
p.maj@ecu.edu.au

Abstract—There are a range of network management tools. One of the simplest, but most commonly used, is the hierarchical text based Command Line Interface (CLI). However, CLI commands typically provide a lot of unnecessary data. Furthermore to manage one protocol operating on a single network device may require a number of different CLI commands. These problems are exacerbated when managing an operational network consisting of populations of different devices each running a number of different protocols. The GUI based CiscoWorks appears to be not widely used. State Model Diagrams (SMDs) extract and diagrammatically integrate the output from different CLI outputs and hence succinctly describe protocol operation. Furthermore, SMDs may be used to describe not only different protocols but also different network devices such as routers, switches, wireless access points etc. SMDs also provide top down decomposition thereby enabling a large complex network to be partitioned into independent units of an amenable size. Using SMDs it is possible to examine the overview of an entire network and also obtain increasing levels of detail whilst still maintaining links and interfaces between the different levels. SMDs have been successfully used as the pedagogical basis of network curriculum. The paper presents the results of a further more extensive pedagogical evaluation. Furthermore, SMDs were evaluated as a network management tool. The results clearly demonstrated that SMD's were found to be as useful as the CLI for all aspects of network management and, significantly, more useful than Ciscoworks.

Keywords: State Model diagrams; network management, Cisco, CCNA, CCNP

I. INTRODUCTION

Network management includes any operation that attempts to control networks. According to Broek and Looijen [1] the cost of managing a network exceeds the purchase cost of the equipment. The roles of network management may be interpreted differently depending upon the role of the network administrator. According to Stallings, network management is,

'The process of using hardware and software by trained personnel to monitor the status of network components and line facilities, implement or recommend actions to alleviate outages or to improve communications performance as well as conduct administrative tasks associated with the network.' [2]

There are five generally recognized requirements of network management: device configuration; fault finding; network

security; performance monitoring and accounting. A typical network is likely to consist of different network devices each running a number of protocols for example: managed switches e.g. Spanning Tree Protocol, Virtual LANs, sub-interfaces; Routers e.g. sub-interfaces, Open Shortest Path First; PIX firewalls e.g. Static address translation, Network Address Translation, Port Address Translation, Standard or Extended Access Control Lists; Wireless Access Points e.g. basic, standard or extended service set. On large networks there may be hundreds of devices. Network management is taught in the Cisco Network Academy Program.

II. CISCO NETWORK ACADEMY

Cisco is the world's largest supplier of network equipment with a worldwide market share of 80-90%. In the late 1990's Cisco introduced, at the cost of US\$25 million the Cisco Network Academy Program (CNAP). Over a 3 year period Cisco invested over US\$50 million in the development of this curriculum, associated website (multi-media training materials) and its assessment and accreditation system. This is now the world's largest and most successful network curriculum operational in over 150 countries. The Cisco Certified Network Associate (CCNA) award is a prerequisite to the more advanced Cisco Certified Network Professional (CCNP) award. Aspects of network management are taught throughout both these awards.

An extensive analysis of CCNA and CCNP curricula found that it primarily teaches internetworking device functionality via case studies using the Command Line Interface (CLI) [3]. The CLI allows the user to determine and modify the status of the various components of a device such as routing table entries, Address Resolution Protocol (ARP) table entries, interface status etc. However a single CLI command may produce output that must be interpreted and also the hierarchical nature of CLI commands is often difficult for novices to understand. Furthermore the status information of the many different device protocols, interfaces etc must typically be obtained by a number of different CLI commands. This may be problematic during teaching when it is necessary to integrate all of this information from a number of different, and possibly complex, CLI commands. Because of this students have problems identifying and understanding the

concepts underlying the use of the CLI. It should be noted however that for experienced network engineers the CLI is a very powerful and useful tool. It was also found that these devices are typically defined as 'black boxes'. While the internal functioning of black boxes can be inferred from input and output behaviour, this is not a good teaching strategy [4].

III. MODELING

Complex systems may be better understood and managed by means of models based upon the principle of abstraction and common threads. Accordingly the ACM/IEEE-CS Joint Curriculum Task Force defined a number of underlying principles for curriculum design that included three processes - theory, abstraction and design. Furthermore abstraction was identified as a recurring concept,

'Levels of abstraction: the nature and use of abstraction in computing; the use of abstraction in managing complexity, structuring systems, hiding details, and capturing recurring patterns; the ability to represent an entity or system by abstractions having different levels of detail and specificity. Examples include levels of hardware description, levels of specificity within an object hierarchy, the notion of generics in programming languages, and the levels of detail provided in a problem solution from specifications through code.' [5]

Even though computer and network technology are subject to rapid technological changes the theme of abstraction has persisted in curriculum design. According to Computing Curricula 2001,

'All computer science students must learn to integrate theory and practice, to recognize the importance of abstraction, and to appreciate the value of good engineering design.' [6]

Computing Curricula 2001 also recognized that the traditional 'bottom up' approach to curriculum mitigates against a systems approach and may be problematic.

'Such an approach (bottom up) works well for students who prefer to understand the process of computation in all of its reductionist detail. It is less effective at encouraging students to see the holistic concepts beyond the mechanics of implementation.'

Ideally any high level systems engineering approach should fully articulate with essential lower level detailed operational characteristics. The Computing Curricula 2005 overview report makes the point that,

'System level perspective – Graduates should appreciate the concept of a computer system, the design of the hardware and software for that system, and the processes involved in constructing and analysing it. They should have an understanding of its operation that goes to a greater depth than a mere external appreciation of what the system does or the way(s) in which one uses it.' [7]

Models are based on abstraction. There exist a wide range of modeling methods each with its own strengths and weakness. Modeling characteristics considered of particular

importance in this application are: diagrammatic, ease of use, ability to control detail by means of hierarchical top down decomposition and also the integration of the status of the different components of a router.

IV. STATE MODEL DIAGRAMS (SMDs)

In order to address the problems associated with the Cisco Network Academy curriculum Maj et al proposed State Model Diagrams (SMDs) for modeling network devices [8]. According to Maj,

'Using the state diagrams for the internetworking devices switch and router it is possible to capture on a single diagram the information from a number of different hierarchical CLI commands.' [3]

By example to determine the operational status of a router running the routing protocol RIP requires the output from four different CLI commands (show interface fa0/1, show interface fa0/0, show arp, show ip route). The output for a single CLI command, the show ip route, is as follows:

Router1#show ip route

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BG, D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area, N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2, E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP, i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area, * - candidate default, U - per-user static route, o - ODR, P - periodic downloaded static route. Gateway of last resort is not set

C 192.168.1.0/24 is directly connected, FastEthernet0/1

C 192.168.2.0/24 is directly connected, FastEthernet0/0

R 192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:03, FastEthernet0/0

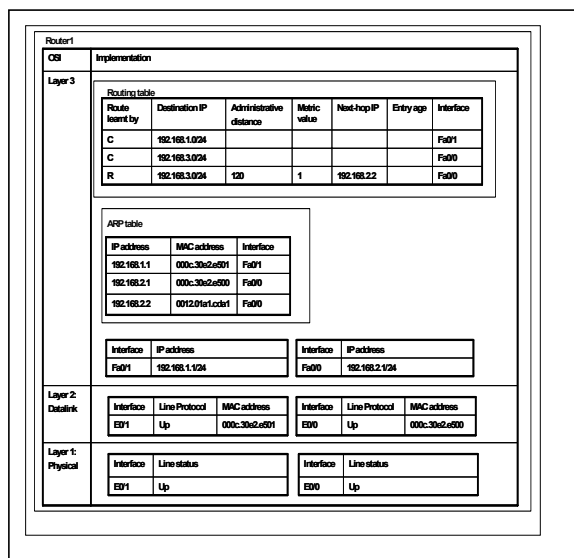


Fig. 1. Router running RIP

Relevant data from these four different CLI commands (show interface fa0/1, show interface fa0/0, show arp, show ip route) can be extracted and represented in a single State Model Diagram all linked to the appropriate OSI level (Fig. 1).

Using SMDs it is possible to apply the same basic principles to other routing protocols,

'Furthermore the modularity allows one to have a basic model (e.g. a router running the RIP routing protocol) whose functionality can be enhanced by the inclusion of additional state tables. Hence the router state model can be used for all the main Interior Gateway Protocols – distance vector (Interior Gateway Routing Protocol – IGRP), link state (Open Shortest Path First – OSPF) and balanced hybrid (Enhanced Interior Gateway Routing Protocol – EIGRP). [3]

By example, a router running the OSPF routing protocol can be modelled using the same SMD with the addition of two more tables (adjacency and topology) and also the association of Designated Router (DR) and Backup Designated Router (BDR) with each interface (OSI layer 3).

In effect students do not have to learn a new conceptual model, rather they can build upon and extend their existing knowledge. In this context new knowledge reinforces existing knowledge.

The SMDs were used as the pedagogical foundation of a network technology curriculum and the results evaluated. It was found that,

'Postgraduate students, whose learning was based upon the state models, demonstrated a comprehension of devices comparable to a qualified and experienced expert in this field. Furthermore these students performed significantly better than other students both within the same and a different institution.' [9].

Further work also supported these findings [10]. These initial studies were extended in order to measure the change in learning throughout an entire semester for students taught using standard curriculum and those taught using curriculum based on the SMDs. The results strongly suggested that the models significantly enhance learning,

'This indicates that both groups of students learnt the required material equally well. However, from the diagrams of the state model students it can be inferred that they have richer conceptual understandings and these are aligned with those of the expert. Consequently they will be more able in future learning to progress towards the end state of the expert's understanding. They are more likely to retain learnt material as this material is linked to more and better concepts thus enhancing recall.' [11]

V. FURTHER PEDAGOGICAL EVALUATIONS

At this university, postgraduate students are able to study the CCNA and CCNP curriculum as part of their award.

Furthermore they have the option to also study two network technology units (5106, 5206) both of which are based on SMDs. Three groups of students were identified:

Group 1 (23 students) had studied 5106 and 5206;

Group 2 (2 students) had studied 5106, 5206 and the CCNA;

Group 3 (6 students) had studied 5106, 5206, CCNA and one or more CCNP units.

All 31 students were also asked to answer the following statements. Each question provided a SMD and the associated command line interface outputs.

S1. State Model Diagrams are modular; hence the same model can be used and extended to explain other technologies. Selected verbatim responses were as follows:

Group 1: *'In fact the state model diagrams are very useful in teaching students to extract layer wise configurations and their behaviours. In general CCNA or CCNP programs, there are no such teaching criteria. In my opinion the way of teaching with model diagrams is excellent and easily understood for students.'*

Group 2: *'Visual diagrams are easier to understand than lengthy written explanations. Therefore, it is good that the state model can be used and extended to explain a variety of different technologies.'*

Group 3: *'As far as teaching is concerned, state model diagram is the easiest way to teach networking subject.'*

For this question, there were no negative comments.

S2. The State Model Diagrams can be used to extract data from the command line interface and display it in table in a single SMD. Selected verbatim responses were as follows:

Group 1: *'From the mode, you are able to tell which devices are connected to the router and on which interface they are connected to.'*

Group 2: *'It helps students understand not only what is going on in a device but also communication between devices.'*

Group 3: *'Very well presented. The output on the hyper terminal seems too difficult to understand but when you present it the way presented above, it really helps students to understand.'*

Again, no negative comments were provided from any of the groups.

S3. When first introduced State Model Diagrams incorporate the OSI model which can then be dropped. This allows other protocols to be incorporated into the SMDs. Selected verbatim responses were as follows:

Group 1: *'The figure with the layers is very comfortable and easy to understand, the data is related to which layer.'*

Group 2: *'By doing this it is easier to understand the whole networking concept than the traditional OSI model because there is actual information listing beside the OSI layer.'*

Group 3: *'It's perfect.'*

Only two negative comments were recorded as follows:

Group 1: *'It's more confusing.'*

Group 3: *'Second diagram blurs the victim of understanding 3 layers of OSI model (1, 2 and 3).'*

S4. Within a network, a single protocol (e.g. RIP) may be running on a number of different routers. As such the devices and protocols interact. To capture such interactions needs the output from a number of different command line interface commands (e.g. show IP route) for each device. The State Model Diagrams attempt to capture relevant output from all these different commands for each device and display the results in a single diagram. Selected verbatim responses were as follows:

Group 1: *'Very good for summarizing the whole system. Makes it easy to see how the ARP tables follow the other devices.'*

Group 2: *'This gives clear understanding of interaction between devices.'*

Group 3: *'I am considering this is the best use of SMD.'*

Again only two negative comments were recorded as follows:

Group 1: *'The figure contains lost of information and for beginner is hard to cope.'*

Group 3: *'I get confused with the "c" in the column heading of the routing table with the "c" of the directly connected network.'*

S5. If a network is not working properly did you use State Model Diagrams for fault diagnosis? Selected verbatim responses were as follows:

Group 1: *'That is the first thing I would do while having that problem.'*

Group 2: *'Sometimes I do, but not always because still not familiar enough with the state diagram.'*

Group 3: *'Of course. This is very useful tool.'*

Only two negative comments were recorded, both from group 1, as follows:

Group 1: *'You get wrong info, and it confuses your knowledge.'*

Q6. Any other comments?

No negative comments were recorded. Selected verbatim responses were as follows:

Group 1: *'The best model I ever saw.'*

'SMD should be standard in teaching networking unit.'

'I feel SMD makes it easy to understand what you are actually doing in your network.'

Group 2: *'The teaching method is excellent and the efforts to construct them is appreciated, but there should be some alternative for the clear practice without having use of the print outs.'*

Group 3: *'I don't know who was the pioneer of this kind of approach in teaching networking. But yes, I would surely like to congratulate the students who are studying under Paul here. They are lucky enough to learn networking in a better and more efficient way. Believe me, I have studied outside (name of university removed) as well and that is why I can feel the difference.'*

In summary for all six questions, group 1 with 23 students who had studied networking curriculum based only on State Model Diagrams provided four negative comments. Group 2 with 2 students who had studied curriculum based on SMDs and the Cisco CCNA curriculum provide no negative answers to any of the six questions. Group 3 who had studied curriculum based on SMDs, the Cisco CCNA and one or more CCNP units provided two negative comments.

All 31 students were asked to evaluate the SMD as a teaching tool using a Likert scale. Only 27 students responded to this question but significantly there were no low ranking responses from any of the three groups shown in Table I.

TABLE I

SMDs AS A TEACHING TOOL

	Rank				
	5 (best)	4	3	2	1 (worst)
Group 1	12	9			
Group 2		1			
Group 3	2	2			
	55.5%	40.7%			

The results suggest that students taught using only SMDs consider that they assisted both their learning and understanding. Significantly, it would appear that students taught using SMDs and the standard Cisco curriculum also considered that SMDs assisted in their learning and understanding.

VI. NETWORK MANAGEMENT

The CCNP award consists of four modules: Multilayer Switched Networks; Scalable Networks; Remote Access Networks and Internetwork Troubleshooting. The Internetwork Troubleshooting curriculum teaches the principles of network management and fault diagnosis. A variety of different network management tools and techniques are taught. There are five generally recognized requirements of network management: device configuration; fault finding; network security; performance monitoring and accounting. However other aspects of network management include documentation. The documentation should be such that it

facilitates fault diagnosis and the integration of new technologies into the network.

One of the simplest, but most commonly used, is the hierarchical text based Command Line Interface (CLI). However, CLI commands typically provide a lot of unnecessary data. Furthermore to manage one protocol operating on a single network device may require a number of different CLI commands. These problems are exacerbated when managing an operational network that consists of populations of different devices each running different protocol.

SMDs can be used to model different devices operating a number of different protocols. Furthermore, SMDs are modular and hierarchical thereby providing top down decomposition by means of leveling. Hence using SMDs it is possible to partition a complex network into independent units of an amenable size so that the entire system can be more easily understood. Using SMDs it is possible to examine the overview of an entire network and also obtain increasing levels of detail whilst still maintaining links and interfaces between the different levels. SMDs were evaluated as a network management tool by five students. All students had completed the two units (5106 and 5206) based entirely on SMDs. One student has also completed the CCNA; two students had also completed one CCNP unit (Scalable networks) and one student has also completed two other CCNP units (Remote Access and Troubleshooting). Only one student (#4) had any relevant commercial experience in networking.

All students were provided with five operation networks, each of increasing complexity as follows:

Network 1: Modems (x2), Routers (x2)

Network 2: Modems (x2), Routers (x2), Managed Switches (x2)

Network 3: Modems (x2), Routers (x2), Managed Switches (x3), Wireless Access Points (x2)

Network 4: Modems (x2), Routers (x2), Managed Switches (x3), Wireless Access Points (x2), Virtual LANs (VLANs)

Network 5: Modems (x2), Routers (x2), Managed Switches (x3), Wireless Access Points (x2), VLANs, PIX firewall (x1)

TABLE II

CLI	#1	#2	#3	#4	#5
Aid to documentation	3	4	4	5	4
Aid to understanding	3	5	4	5	4
Usefulness for fault diagnosis	3	4	4	4	2

The volunteers were asked to manage each network using whatever tools and techniques they wished. The CLI, SMDs and a commonly available network management tool (Ciscoworks). The volunteers were asked to rate each network

management tool (CLI, SMD and Ciscoworks) using a Likert scale (5 best, 1 worst). The results clearly indicated that the students found both the CLI and SMDs equally useful as network management tools. None of the students made use of Ciscoworks (Table II, III). No students reported using Ciscoworks.

TABLE III

SMDs	#1	#2	#3	#4	#5
Aid to documentation	5	4	5	5	5
Aid to understanding	5	4	4	5	3
Usefulness for fault diagnosis	5	4	5	3	5

It is incumbent upon network managers to integrate any new technologies, for which they may not have extensive experience, into their existing operational network. The five volunteers were asked to manage network 5 that included a technology that none of them were familiar with – a firewall. Again they were asked to rate each network management tool (CLI, SMD and Ciscoworks) using a Likert scale (5 best, 1 worst). The results clearly show that both CLI and SMD were found to be useful. SMDs were however considered more useful than the CLI. Again no students used Ciscoworks to manage the network (Table IV, V). No students reported using Ciscoworks.

TABLE IV

CLI	#1	#2	#3	#4	#5
Documentation	2	4	4	5	3
Understanding	2	4	4	5	4
Fault diagnosis	2	3	4	4	2
Overall usefulness	2	4	3	3	3

TABLE V

SMDs	#1	#2	#3	#4	#5
Documentation	5	4	5	5	5
Understanding	5	4	4	5	4
Fault diagnosis	4	3	5	4	5
Overall usefulness	4	4	5	4	5

The results suggest that SMD's were found to be as useful as the standard CLI for all aspects of network management (documentation and understanding network operation, fault diagnosis and the introduction of new technologies).

VII. PEDAGOGICAL INTERPRETATION OF RESULTS

The Cisco curriculum is designed to teach 'industry ready' students and hence emphasises workshops based on equipment

they may well meet in the workplace. Learning in a real life context is variously referred to as 'situated cognition' or 'authentic learning'. The results suggest that the students used SMDs as part of their learning experience. This is potentially important because according to Brown,

'People who use tools actively rather than just acquire them, by contrast build an increasingly rich implicit understanding of the world in which they use the tools and of the tools themselves.' [12]

Furthermore the students demonstrated that SMDs were used to solve problems that they had never encountered before. This is important because according to Bloom,

'A problem in the comprehension category requires the student to know an abstraction well enough that he can correctly demonstrate its use when specifically requested to do so. "Application" however, requires a step beyond this. Given a problem new to the student, he will apply the appropriate abstraction without having to be prompted as to which abstraction is correct or without having to be shown how to use it in that situation.' [13]

CONCLUSIONS

Previous research has demonstrated that when network technology curriculum is based on the State Model Diagrams there are potentially significant pedagogical benefits. This paper also found that curriculum based upon SMDs assists learning and understanding. Furthermore, students who had studied curriculum based on SMDs and the standard Cisco curriculum still considered SMDs to be of educational value. Network management is an important aspect of network technology curriculum. Throughout the Cisco CCNA and CCNP curriculum network management techniques are taught. However there is one specific CCNP unit concerned with network management – Internetwork Troubleshooting. This unit teaches a variety of network management tools and techniques. Previous research has shown that SMDs allow a large complex network to be partitioned into independent units of an amenable size. As such SMDs are potentially a useful network management tool. The results clearly indicated that students found both the CLI and SMDs equally useful for network management (documentation and understanding network operation, fault diagnosis and the introduction of new technologies). Furthermore, the students voluntarily elected to use SMDs when presented a problem that was new to them. This indicates Bloom cognitive domain taxonomy level 3 i.e. Application. It is accepted that there were a limited number of student in the second experiment; hence further more extensive studies are needed.

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Cooperative Learning Objects in a Federated Learning System

S. Encheva
Stord/Haugesund University College
Department Haugesund
Bjørnsonsg. 45, 5528 Haugesund
Norway

S. Tumin
University of Bergen
IT Department
P.O.Box 7800, 5020 Bergen
Norway

Abstract—Course design costs a significant part of a WEB-based learning project budget. A big cost reduction is possible if the involved learning objects are reusable and are shared among collaborative organizations. This paper describes a system based on a flexible framework that provides the instructors and students with possibilities in designing courses using shared, reusable learning objects.

I. INTRODUCTION

Course design costs a significant part of a WEB-based learning project budget. A big cost reduction is possible if as many learning objects (LOs) as possible are reusable and are shared among collaborative organizations.

One of the alternative approaches to content development is involvement of reusable learning objects. Some requirements for a LO are – it must have a description that enables lectures to search for and find the most suitable LO, the system automatically leads the learner from one LO to another and every LO should be able to become a part of the system using methods that are independent of the system, no restrictions on the size of a particular LO.

Consider a lecturer affiliated with an educational institution that is member of a federated learning system, who is trying to build a new course. Suppose the system is able to provide a large number of LOs upon the lecturer request. A lot of time and efforts can be spared if the system can first filter and rank those LOs according to the lecturer's preferences. The system can help both the lecturer and the students by presenting each student with a LO chosen from the related set of selected LOs but tailored according to the student's individual learning styles and preferences. Involvement of a student's learning style helps learning to be orientated according to the preferred method. Our goal is to develop a framework of how to enable a lecturer to build new courses and/or update existing ones by reusing LOs developed at different educational institutions that are members a federated learning system.

The model is composed of a base system, runtime support, and agents.

The paper is organized as follows. Section 2 contains some terms and definitions that are used later in the presentation, and a description of related work. The system model is described in Section 3 and the system architecture is presented in Section 4. The paper ends with a conclusion in Section 5.

II. PRELIMINARIES

A lattice is a partially ordered set, closed under least upper and greatest lower bounds. The least upper bound of x and y is called the join of x and y , and is sometimes written as $x + y$, the greatest lower bound is called the meet.

X is a sublattice of Y if Y is a lattice, X is a subset of Y and X is a lattice with the same join and meet operations as Y .

A concept lattice [3] is a structured graph for representing knowledge, so that the structure can be used in the representation system. A context is a triple $K(G, M, I)$ where G and M are sets and I is a relation between G and M . G is called the set of objects and M is the set of attributes. A big advantage of the lattice structures that are available when working with relations is the abundant possibility for using Galois connections. The elements of the lattice represent all inductively defined datatypes for a given structure. This Galois connection, which defines a closure operation, turns out to be very convenient for proving properties of different datatypes.

A learning style is the general, habitual mode of processing information; it is a predisposition on the part of some students to adopt a particular learning strategy regardless of the specific demands of the learning task: that is, individuals' learning styles are simply the cognitive styles that they evidence when confronted with a learning task.

According to the Kolb's model, there are four learners' types:

- diverging (feeling and watching) – perform better in brainstorming situations, prefer to work in groups and to receive personal feedback;
- assimilating (watching and thinking) – concise, logical approach, prefer readings, lectures, exploring analytical models, and having time to think things through;

- converging (doing and thinking) - like to experiment with new ideas, to simulate, and to work with practical applications;
- accomodating (doing and feeling) - prefer to work in teams to complete tasks use other people's analysis, and prefer to take a practical, experiential approach.

The three learning preferences are auditory (learning by hearing), visual (learning by seeing), and kinesthetic (learning by doing)

The transforming learners [6] place great importance on personal strengths, ability, persistent effort, strategies, high-standards, and positive expectations to self-direct intentional learning successfully.

They use stimulating influences, such as intentions, motivation, passions, personal principles and high standards, to direct achievement of challenging personal goals. They prefer loosely structured learning environments that encourage and support positive anticipations, expertise building, risk-taking experiences, mentoring relationships, self-directed learning, problem-solving situations, support for high learner control opportunities, transformative processes, high learning standards, and achievement of challenging personal goals for long-term accomplishments and change.

The performing learners [6] are non-risk, skilled learners that consciously, systematically, and capably use cognitive processes, strategies, preferences as they focus on grades and attaining normative achievement standards.

They are short-term and task-oriented, take fewer risks with challenging or difficult goals, and rely on coaching relationships and available external resources and influences to accomplish a task. Performing learners clearly acknowledge meeting only the stated objectives, limiting effort, getting the grade, and avoiding exploratory steps beyond the learning task.

They prefer semi-structured learning environments and seldom solely rely on compliance, others for motivation, or explicit direction and feedback.

The conforming learners [6] are compliant, passively accept knowledge, store it, and reproduce it to conform, complete assigned tasks if they can, and please others.

They do not typically think critically, synthesize feedback, solve complex problems, make independent decisions, or give knowledge new meaning to initiate change in themselves or the environment. These learners are typically less skilled learners who have little desire to control or manage their learning or change their environment.

They prefer to have simple standards set for them, expend less effort, and receive explicit guidance and feedback as they accomplish required tasks. These learners learn best in environments that are safe, structured, focus on step-by-step procedures, and offer easily attained short-term goals.

Resistant learners [6] lack a fundamental belief that academic learning and achievement can help them achieve personal goals or initiate positive change. These learners do not believe that formal education or academic institutions can be positive or enjoyable influences in their life.

The Sharable Courseware Object Reference Model (SCORM) provides technical standards that enable web-based learning systems to find, import, share, reuse, and export learning content in a standardized way. SCORM is written for developers and toolmakers who build Learning Management Systems and learning content authoring tools. SCORM is isintended to standardize how to launch and track directed learning experiences, and to define the intended behavior and logic of complex learning experiences so content can be reused, moved, searched for, and recontextualized.

IEEE Learning Object Metadata (LOM) defines a set of resource description framework constructs that facilitates introduction of educational metadata into the semantic web.

HarvestRoad Hive is an independent, federated digital repository system. It enables the collection, management, discovery, sharing and reuse of LOs. This digital repository project has been developed as a solution to different repository purposes a system would have. The stored objects can be grouped in different bureaus. Each bureau can be searched separately or by federated search. Each bureau can be established with customised security permissions, workflows attached to item types and can consists of many categories or sub-collections.

Top-down and bottom-up strategies for the development of tightly coupled, federated information systems are presented in [2].

A reference model and infrastructure for federated learning content repositories are developed in [7]. Uncertainties in the database integration process were analyzed [1]. Engineering federated information systems are discussed by many authors, e.g. [4], [5] and [8].

III. THE MODEL

The system is based on a flexible framework that provides the instructors and students with possibilities in designing courses using shared, reusable LOs. A subject is defined as a strictly sequential list of topics by a course builder. Each subject definition is saved in the database in XML. The subject's definition contains all the metadata needed to uniquely describe the subject in question. A topic is composed of theoretical parts, exercises, examples, drills, and assessments, where some of them can be empty. Any of them is a LO designed by expert instructors.

Each topic is defined by the course builder in XML and saved in the database. Topics are defined dynamically by diagnostic components of the system.

The drills' design contains inference rules analyzing

Table 1. Context for different educational units

Lecture notes Examples Assessments	Bachelor, Master and PhD Programs for Different Educational Units											
	1B	1M	1P	2B	2M	2P	3B	3M	3P	4B	4M	4P
HTML 1	x			x		x		x				
HTML 2		x			x				x			x
HTML 3	x	x					x			x		
HTML 4			x			x					x	
PDF 1	x			x				x				
PDF 2		x			x				x			x
PDF 3	x	x			x	x					x	
PDF 4							x			x		
Flash 1	x		x					x				x
Flash 2		x		x					x			
Java-applet 1	x	x				x	x			x		
Java-applet 2					x						x	
Static Example	x			x					x			x
Interactive Example Flash 1		x	x			x					x	
Interactive Example Flash 2	x	x			x					x		
Interactive Example Java 1			x						x			
Interactive Example Java 2	x			x				x			x	
Multiple Choice Test		x			x		x					x
Compulsary Assignments	x	x				x				x		

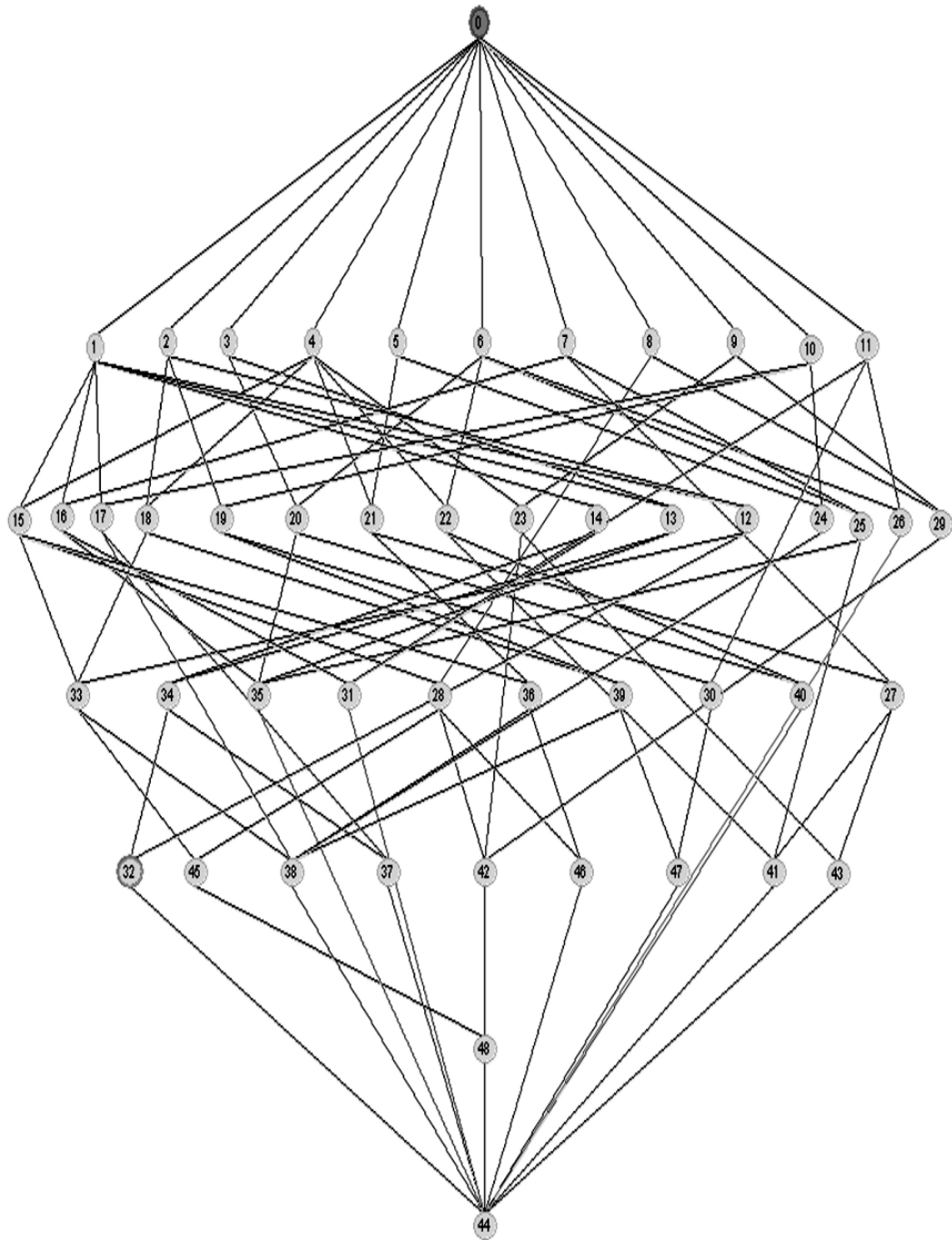


Fig. 1. Hasse-diagram for different educational units

students' answers to carefully prepared tests. Students' test scores and wrong responses are used as input parameters to a diagnostic component in the drills, which provides recommendations to alternative personal topic trails containing relevant LOs in order to solve the current topic's drill.

For the sake of simplicity we limit the amount of educational units, study programs and related attributes to the ones included in Table 1.

The abbreviated objects are:

- Lecture notes presented as HTML 1, 2, 3, 4 according to the four learner orientations- transforming, performing, conforming, and resistant;
- Lecture notes presented as PDF 1, 2, 3, 4 according to the four learners types - concrete, reflective; abstract, reflective; abstract, active; and concrete, active.
- Lecture notes presented as Flash 1, 2 according to the two learning preferences - learning by hearing, and learning by seeing
- Lecture notes presented as Java-applets 1, 2 according to the level of difficulties
- Interactive examples presented as Flash 1, 2 according to two learning preferences - learning by hearing, and learning by seeing
- Interactive examples presented as Java-applets 1, 2 according to the level of difficulties

The corresponding concept lattice is shown in Fig. 1.

IV. THE SYSTEM

Apache is used as a Web server with a Python interpreter extension using a `mod_python` module. PostgreSQL is used as a relational database that supports Structured Query Language.

Dynamic HTML pages are created by server-side scripts written in Python. Python programs are also used for database integration, diagnostics, and communication modules.

The system structure defines dependencies among learning materials, levels and relationships between tests options, and inference rules used in a diagnostic agent. This structure is crucial in providing each student with a personalized learning work-flow for efficient learning. The responses from each student to the suggestions from the system provide the diagnostic agent with necessary data. The diagnostic agent analyzes these data using the programmed inference rules and provides the student with an immediate recommendation on how to proceed.

An agent is first checking whether all definitions and statements required are included in the suggested LOs. Another agent determines whether the level of difficulties assumed for the new LOs corresponds to the level of difficulties of the suggested LOs. The student's learning material subscriptions are placed in a stack-like structure in the student profile data. The student profile agent presents the student with the top most learning

material in the profile stack for each new learning session.

Initially, the profile stack contains a sequential ordering of learning materials in a given subject. A student can choose to skip any presented learning material and go to the next one at any time. A student is considered to have completed a course when his/her profile stack is empty and he/she has passed all compulsory tests assigned to the course.

All learning material names taken by the student during the course and scores of the tests are saved in the student audit-trail. Such audit-trail data is used for billing purposes while global analysis of the course and feedback data is used to improve learning materials for each subject.

The server-side scripts contains student and teacher modules. Server-side scripts modules and agents communicate with each other by a request-response mechanism in which remote procedure calls are done among different modules/agents providing students with a dynamic and personalized learning environment.

A pedagogically crafted scheme with a set of questions and answers provides a test agent with a programmed intelligence, in which wrong answers to a drill lead learners to appropriate hints and examples. The agent calculates scores, shows result status, and keeps track of assessments taken by each student. After each assessment the test agent sends summarized information to the diagnostic agent.

In the recommendation on how to proceed, a student can choose to subscribe to one or more suggested LOs. The student's LO subscriptions are placed in a stack-like structure in the student profile data.

Initially, the profile stack contains a sequential ordering of LOs in a given subject. A student is considered to have completed a course when her/his profile stack is empty and she/he has passed all compulsory tests assigned to the course. All element names taken by the user during the course and scores of the tests are saved in the user audit-trail. Such audit-trail data is used for billing purposes while global analysis of the course and feedback data is used to improve contents and tests for each subject.

The curriculum of each subject at every educational unit should be described using a set of agreed upon metadata presented in a standard structure in a database.

If LOs in a course are connected with hyperlinks, the course builder risks to end up with some dead links during the semester. If all LOs in a course are cached on a local server, the course builder is sure that all LOs are going to be available to the students through the entire semester. The owners of the LOs can include f. ex. 1x1 pixel gif picture in every LO. Thus the owners will get information from log files for the number of times a LO has been used and by how many different users.

V. CONCLUSION

Reusable LOs are a meaningful and effective way of creating content for e-learning. Their development needs a cooperative model assisting lectures to build up courses satisfying the individual needs of each student and fulfilling subject requirements.

This work presents a model illustrating how learning objects can be reused by educational institutions, members of a federated learning system.

The paper focuses on a framework for building new courses or updating existing ones by choosing learning objects developed at educational units that are members of a federated learning system. The aim of this work is twofold. First assisting a lecturer in collecting learning objects closest to the lecturer's vision on what a subject should contain and how the content should be presented. Secondly, present a student with content, tailored according to student's individual learning preferences.

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Application of Meet-Distributive Lattices for Assessing Students Knowledge

S. Encheva
Stord/Haugesund University College
Department Haugesund
Bjørnsonsg. 45, 5528 Haugesund
Norway

S. Tumin
University of Bergen
IT Department
P.O.Box 7800, 5020 Bergen
Norway

Abstract—The goal of this paper is to develop a theoretical framework for assessment of learners' level of mastering of lower and upper concepts. The presented work involves the theory of knowledge spaces, distributive lattices and nested line diagrams. Application of distributive lattices in the framework facilitates avoidance of answer combinations that do not contain both lower concepts and related to them upper concepts.

knowledge state of each student in a certain knowledge domain and then provide further guidance and personalized help.

The rest of the paper is organized as follows. Related work is discussed in Section 2. The model description can be found in Section 3. The paper ends with a conclusion in Section 4.

I. INTRODUCTION

Establishing the knowledge state of a student in a subject is crucial for providing him/her with individual help. However, in many occasions it may require a relatively long sequence of questions and thus disturb the flow of the learning process. It might also not be very effective for providing immediate help to the student while he/she is working on a particular part of the curriculum.

In this paper we propose a theoretical framework for assessment of learners' level of mastering of lower and upper concepts. The presented work involves the theory of knowledge spaces, meet-distributive lattices and nested line diagrams. Application of distributive lattices in the framework facilitates avoidance of answer combinations that do not contain both lower concepts and related to them upper concepts.

Nested line diagrams are applied to visualize larger concept lattices, and to emphasize substructures and similarities. Association rules will be applied in the process of choosing appropriate learning materials that the system suggests to a student in a case the student gives incorrect response.

A framework for representing and measuring students' knowledge is developed in [4]. The key concepts in the theory of knowledge spaces are the *knowledge state* - a subset of problems that an individual is capable of solving correctly, and the *knowledge structure* - a distinguished collection of knowledge states.

Assessment and LEarning in Knowledge Spaces (ALEKS) and Relational Adaptive Tutoring Hypertext (RATH) are systems aiming at establishing the

II. RELATED WORK

Subsets of relevant examination questions and certain skills from a branch of knowledge are listed as examples of knowledge states in [5]. They are followed by an important remark that not all possible subsets of such items turn out to be knowledge states. ALEKS is based on mathematical cognitive science and involves computer algorithms while constructing specific knowledge structures. RATH combines mathematical hypertext model and knowledge space theory and is focused on teaching.

Students' conceptual thinking can be assessed by presenting them with tests where all the correct answers should be chosen and/or answers require integration of several components or approaches [2].

An excellent introduction to ordered sets and lattices and to their contemporary applications can be found in [3].

Let Q be a finite set. A family \underline{K} of subsets of Q is a *knowledge space* on Q if

- the empty set and the total set Q are members of the family \underline{K} , and
- the family \underline{K} is closed under union.

Well-graded knowledge spaces are dual to the convex geometries presented in [6]. A finite closure space is a convex geometry if its dual (Q, K) is a knowledge space in which all learning paths are gradations [4].

An atom at item q in knowledge space theory is a minimal knowledge state containing q . A state is called an atom if it is an atom at q for some item q .

A knowledge space is a closure system [4]. A closure system on set M is convex geometry if it satisfies the following properties:

- the empty set is closed
- for every closed set MI different from M there exists m not in MI such that $MI + m$ is a closed set.

A lattice is a partially ordered set, closed under least upper and greatest lower bounds. The least upper bound of x and y is called the join of x and y , and is sometimes written as $x + y$, the greatest lower bound is called the meet.

X is a sublattice of Y if Y is a lattice, X is a subset of Y and X is a lattice with the same join and meet operations as Y . A lattice L is meet-distributive if for each y in L , if x in L is the meet of (all the) elements covered by y , then the interval $[x, y]$ is a boolean algebra.

Convex geometries are closure systems which satisfy anti-exchange property (which is an antipodal concept to the Steinitz MacLane exchange property of matroids), and they are known as dual of antimatroids. Antimatroids can be seen as a combinatorial abstraction of convexity, while matroids can be seen as a combinatorial abstraction of linear independence. Antimatroids are related to matroids in that both can be defined by a apparently similar axioms.

The set of closed sets of a convex geometry, form a lattice when ordered by set inclusion. Such lattices are precisely the meet- distributive lattices. A lattice is said to be infinitely meet-distributive if all existing meets in it are distributive.

A nested lattice is the product of two concept lattices sometimes referred to as inner and outer lattice.

A nested line diagram consists of an outer diagram that contains inner diagrams in each node. Inner diagrams are not necessarily congruent but only substructures of congruent diagrams. Congruent diagrams are shown as structures possessing some unrealized concepts.

Association rule mining finds interesting associations and/or correlation relationships among large set of data items. Association rules show attribute value conditions that occur frequently together in a given dataset. A typical and widely-used example of association rule mining is market basket analysis.

III. THE MODEL

In this model we consider a test with eight questions. A student who answers correctly to at least five questions has mastered at least one of the involved concepts. A student obtaining less than five correct answers is

advised to work on selected teaching materials first and take the test afterwards.

The primary objective of this approach is to determine students understanding of some relatively simple concepts (further on referred to as *lower* concepts) and his/her abilities to apply several lower concepts at the same time (further on referred to as *upper* concepts).

Questions investigating student's mastering of lower concepts are denoted by single letters, a, b, c, d . Questions investigating students ability to apply three of the lower concepts at the same time are denoted by a group of three letters, f. ex. abc . Thus a correct answer to question abc indicates student's ability to apply the concepts from questions a, b and c at the same time.

Fig. 1 illustrates the outer lattice for the eight concepts $a, b, c, d, abc, abd, acd, bcd$.

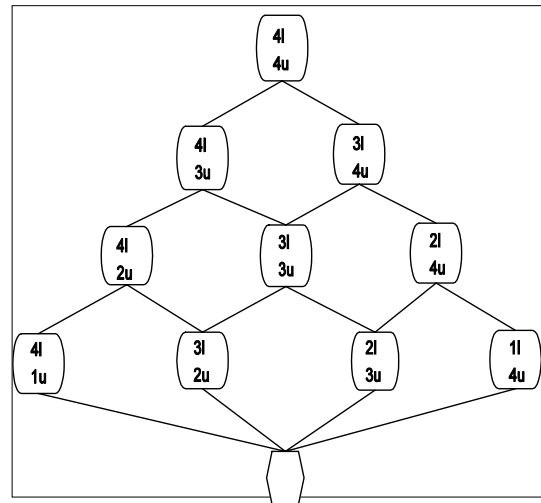


Fig.1. Outer lattice with four lower concepts and four upper concepts

The basic inner lattice is presented on Fig. 2. It illustrates relations among the lower concepts a, b, c, d and the upper concepts abc, abd, acd, bcd .

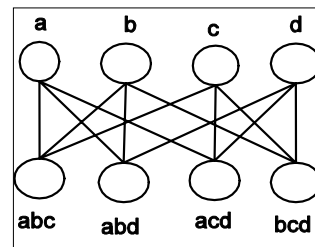


Fig.2. Inner lattice with four lower concepts and four upper concepts

A lower concept a is considered to be mastered by a student if he/she gives correct answers to question a and all related to it upper concepts considered by questions abc, abd, acd . A graphical representation may be seen on Fig. 3. In a consecutive test the student will receive seven questions, i.e. b, c, d, abc, abd, acd and bcd . Graphically we present a correctly answered question by a blackened circle.

The other three cases concerning concepts b, c and d are similar. They are included in a general node denoted $(1l, 4u)$ of the outer lattice on Fig.1.

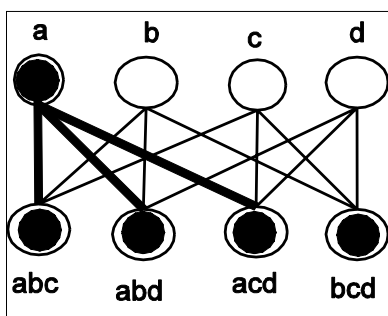


Fig. 3 Inner lattice with one lower concept and four upper concepts

Fig. 4 illustrates one mastered upper concept, abc . The other three cases concerning concepts upper abd, acd and bcd are similar. They are included in a general node denoted $(4l, 1u)$ of the outer lattice on Fig.1.

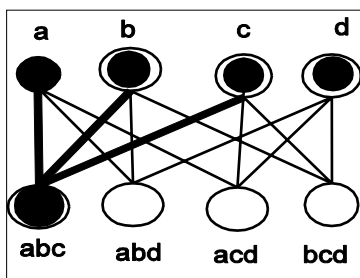


Fig. 4 Inner lattice with four lower concepts and one upper concept

Fig. 5 illustrates one mastered lower concept a . The other three cases concerning concepts $b, c,$ and d are similar. They are included in a general node denoted $(2l, 3u)$ of the outer lattice on Fig.1.

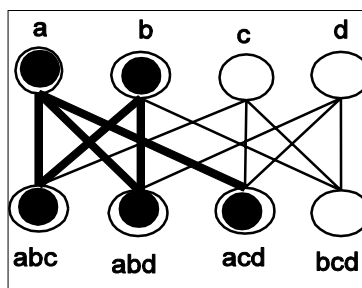


Fig. 5 Inner lattice with two lower concept and three upper concepts

Fig. 6 represents one mastered upper concepts, abd . The other three cases concerning concepts upper abc, acd and bcd are similar. They are included in a general node denoted $(3l, 2u)$ of the outer lattice on Fig.1.

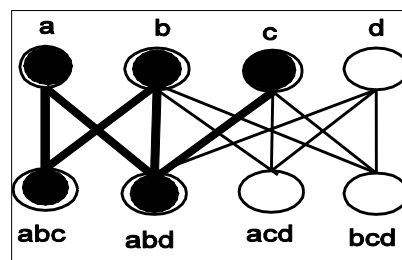


Fig. 6 Inner lattice with three lower concept and two upper concepts

Fig. 7 represents two mastered lower concepts, a and b . The other five cases are similar. They are included in a general node denoted $(2l, 4u)$ of the outer lattice on Fig.1.

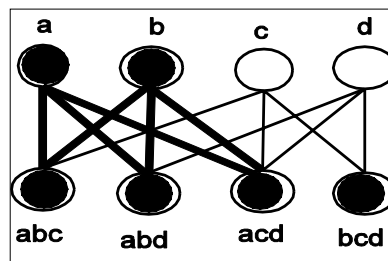


Fig. 7 Inner lattice with two lower concept and four upper concepts

Fig. 8 represents one mastered lower concept, a and one mastered upper concepts abc . The other cases are similar. They are included in a general node denoted $(3l, 3u)$ of the outer lattice on Fig.1.

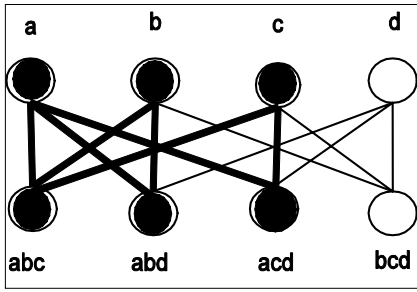


Fig. 8. Inner lattice with three concept and three upper concepts

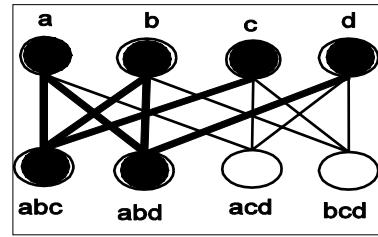


Fig. 9. Inner lattice with four lower concept and two upper concepts

Fig. 9 represents two mastered upper concepts abc and abd . The other cases are similar. They are included in a general node denoted $(4l, 2u)$ of the outer lattice on Fig.1.

Fig. 10 represents two mastered lower concepts, a and b , and three mastered upper concepts abc , abd and acd . The other cases are similar. The other cases are similar. They are included in a general node denoted $(4l, 2u)$ of the outer lattice on Fig.1.

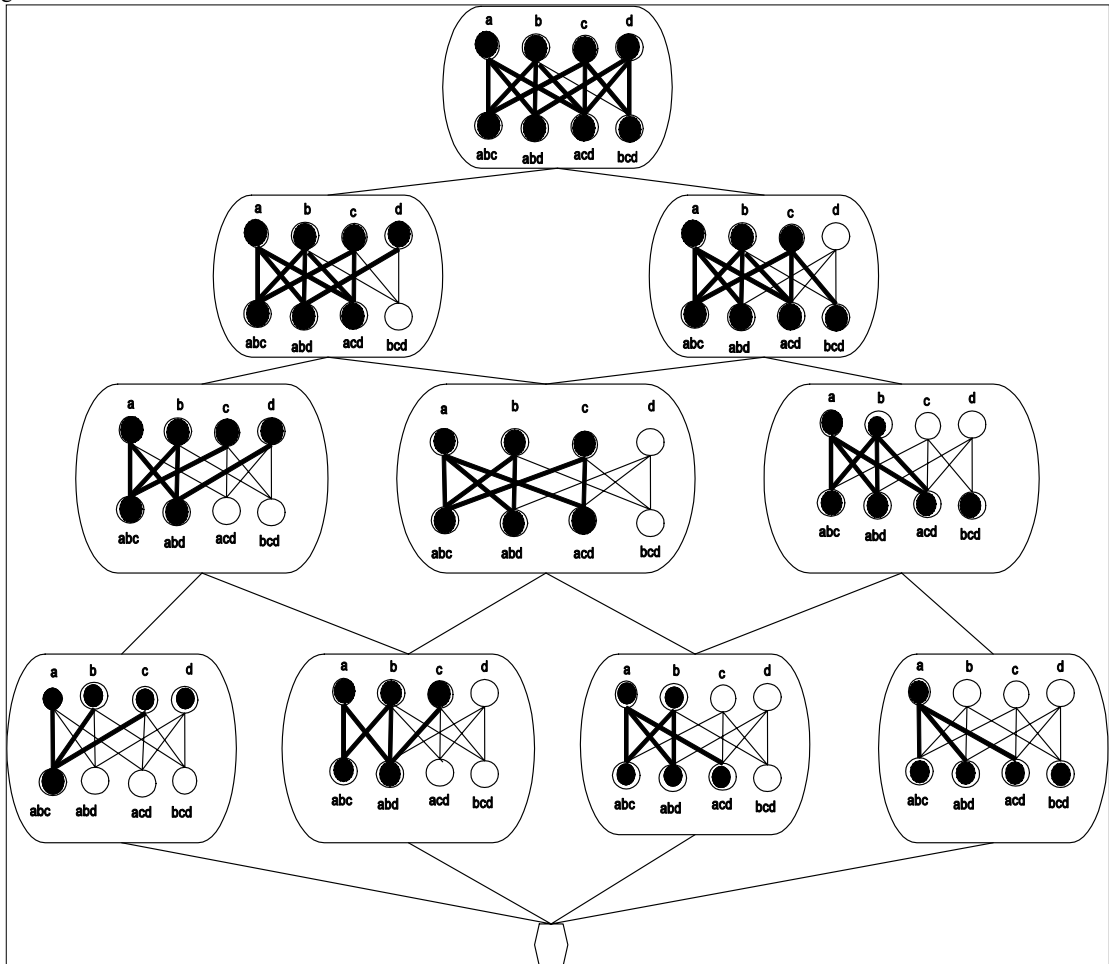


Fig.12. A nested line diagram

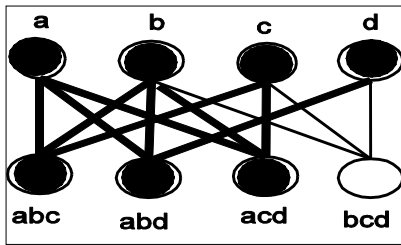


Fig. 10. Inner lattice with four lower concept and three upper concepts

Fig. 11 represents four mastered lower concepts, and four mastered upper concepts. It is included in the general node denoted (4l, 4u) of the outer lattice on Fig.1.

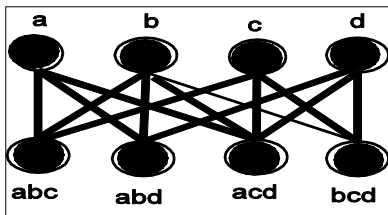


Fig. 11. Inner lattice with four lower concept and four upper concepts

Fig. 12 presents the product of the lattices from Fig. 1 and Fig.2, where the general inner lattice is has some blackened points which correspond to correctly answered questions.

Application of distributive lattices helps to avoid answer combinations that do not contain both lower concepts and related to them upper concepts.

In a case of incorrect answer the student is presented with theory and examples clarifying student's lack of knowledge, misunderstanding or misconception. Such recommendations are given by intelligent agents that base their decisions on using association rules. In case of a consecutive failure the procedure is repeated with another set of questions. If the student answers correctly to all questions the process of questioning is terminated.

IV. CONCLUSION

A theoretical framework for efficient assessment of learners' understanding of carefully chosen concepts is presented. In our next phase of experiments we will evaluate the suitability of the current rules and the effectivity over time of the system. Some association rules will be applied in the process of choosing appropriate learning materials.

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The concept of the internet textbook on theoretical mechanics

E.V. Ponomaryova, T.O. Nevenchannaya, *V.E. Pavlovsky
IEE Conference Publishing

Astrakhan State Technical University, 414025, Astrakhan, Russia

*The Keldysh Institute for Applied Mathematics, Russia Acad. of Sci., 125047, Moscow, Russia

Abstract: The concept, structure and contents of the Internet textbook on classical mechanics intended for Higher Technical Institutions are presented in this work. Aspects of program realization of textbook applications and the technology of elaborating the textbook in the “Hecadem” Internet-teaching environment are given too.

The achievements in the field of information technology help to work out and use computer learning systems (CLS) in the course of teaching process, aimed at performing various types of teaching activity. The main principles of new CLS are the following: interactiveness; dynamics; integrativeness; Web-compatibility; work providing in the off-line mode and distance mode; updating; modeling and simulation of examined processes and phenomena; visualization of educational information; illustration by sound aids; various services; control of knowledge with error diagnostics and feedback.

CLS is a more advanced means as it not only intensify non-textual parts (graphics, animation, video, sound) and various services, as well as, wide opportunities of Internet network.

Such systems we will name hereinafter as distance teaching systems (DTS). Now we consider the most common opportunities of DTS (Fig.1).

The first type (semantic elements): helps to study theoretical material of a subject, consolidate the knowledge of the material covered by solving problems and performing calculations, carrying out computer experiments and exercising intermediate and final knowledge control. These options bring closer DTS and traditional teaching process.

The second type (multimedia options): includes illustration of teaching material with the help of video and sound, animation and graphics as it helps to improve presentation of teaching material and arouse interest for learning.

The third type (interface, services): it includes options of creation of multilevel menu system, multiple window interface, system of hypertext jumps, text look-up. It helps to avoid laborious calculations and it accelerates the process of solving tasks as well as it helps to motivate learners for study and to liven up the work.

The fourth type (Web options): it helps to provide interactive link of a learner and a teacher through Internet (from primitive E-mail to the formation of off-line or on-line conferences), it provides searching of scientific and educational information in Internet and it helps to use references, etc.

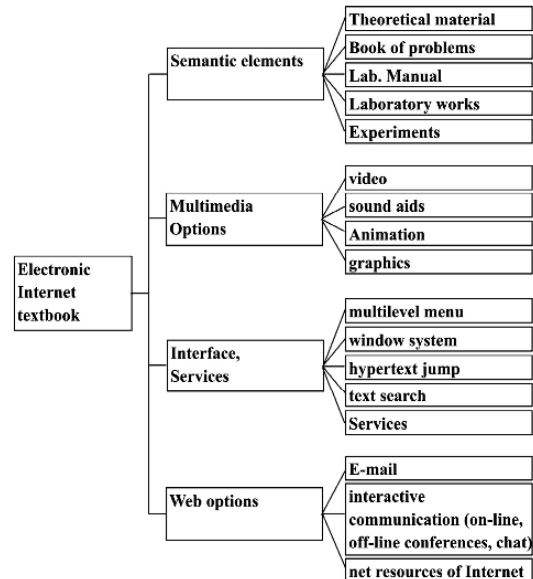


Fig 1. DTS possibilities.

Astrakhan State Technical University together with M.V. Keldysh Institute of Applied Mathematics of Russian Academy of Sciences developed technologies of creation computer distance/local learning system and so DTS on theoretical mechanics was created for this purpose [1], [2].

Computerization learning is of great independent and interdisciplinary importance in the field of theoretical mechanics as this subject is the basis for learning general engineering subjects and special courses as it teaches to highlight the modals for solving formulated problems, to lay down conditions, to solve problems, to determine the limits of their acceptability.

Developed teaching system includes the following parts: organization and information block; electronic Internet-textbook on theoretical mechanics (certificate on official registration of computer program 2004612620, Rospatent); manual aid “Theoretical mechanics on computer”.

Let us consider each part in detail.

1) Organization and information block.

Organization and information block includes: course curriculum with indication of subject list and date of their performing; schedule of laboratory works, seminars and classes; syllabuses; programs; teaching charts; problem exercises; manual aid on theoretical mechanics.

2) CLS on theoretical mechanics.

Let us illustrate the designed textbook (see [1-3] as well) and for its illustration we include the proposed technologies of creation DTS. They are based on the technology and host system of differentiable Internet training "Hecadem" in distance version.

Two versions of textbook were worked out; local and distance ones. These two versions of electronic textbooks were designed in shareable formats and they are Web standards.

Distance version of the textbook assumes the work by global information Internet and it supplies distance development of the textbook in Internet; creation of general array of knowledge elements on mechanics; formation of new teaching courses on mechanics type on the base of created array of knowledge.

Local version of the textbook is designed for work at autonomy device or in local network.

Each version of the textbook includes program appendix:

- "Theoretical material",
- "Tests and problems",
- "Laboratory manual" (fig. 2).

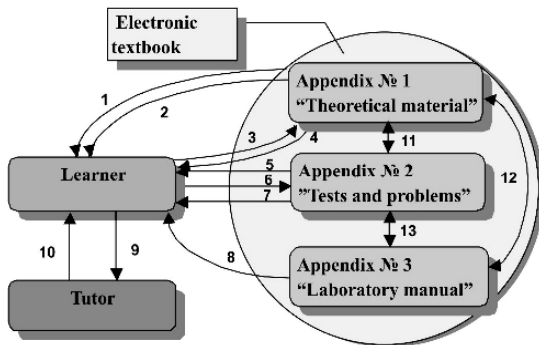


Fig. 2. Scheme of interconnections of a learner and electronic textbook.

When working with appendix 1 a learner is offered to study theoretical material (1), including the main definitions, theories, illustrations for worked standard problems. Each section has been studied, the learner answers the questions (self-evaluation) (2).

Fed answers (3) are transmitted back to appendix 1, which returns the result to the learner after answers being analyzed (4).

When applying to appendix 2 a learner is offered a set of tests and problems (5), and he/she enters the result of a solved problem (6), then it is carried to appendix 2. The answers are analyzed by the appendix and then the result is reported (7).

The interaction of a learner and appendix 3 assumes the participation of a tutor and it is reduced to the following steps: the appendix offers a learner design basis and calculated and graphical work (8). The work being done; the learner passes it to the tutor (9). The tutor evaluates the correctness of work, then the learner is informed the result (10).

Let us consider these appendixes.

Appendix "Theoretical material" contains the theory of studied subject with the examples of solved standard problems. The appendix is performed in the form of two realizations: realization 1, or "Course of lectures" where theoretical material is presented in a logical order as in a typical textbook; realization 2, or "reference-précis", structured according to semantic elements. Hyper textual references help to work on this reference material.

Theoretical material of the textbook is presented in the following parts: "Kinematics", "Statics", "Point dynamics", "Dynamics of a system", "Analytical mechanics", "Calculation of mechanisms".

The first five sections are included into traditional course on theoretical mechanics. Section "Calculation of mechanisms" is also put into the textbook. The textbook is an original authors' teaching aid, the main concepts of mechanics being presented here as well as intersubject approach to the calculation of mechanisms and it helps to use knowledge from different fields for solving the problems [2]. Concepts of composing kinematical design on machine engineering drawing are presented here (fig. 3).

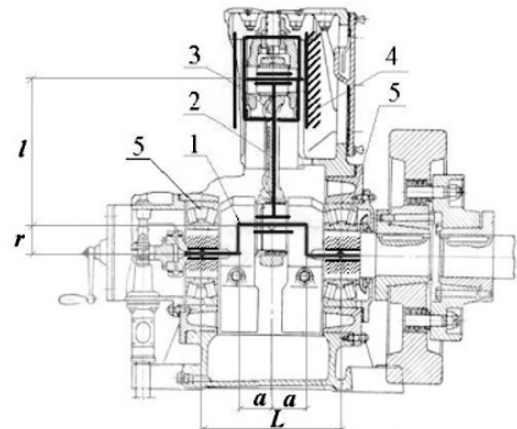


Fig. 3. Machine engineering drawing.

Execution of crank-slider mechanism in the form of a rod and in the form of a circular links are examined in the kinematical circuit design (Fig. 4, 5).

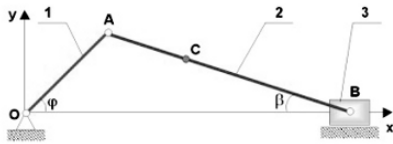


Fig. 4. Kinematical design.

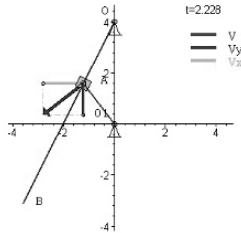
Link OA – crank - executes rotary movements.
 Link AB – coupler - connecting rod-moves plane parallel.
 Link B – slider - reciprocating along the horizontal guide.
 Point O with coordinates (0; 0) is stationary.



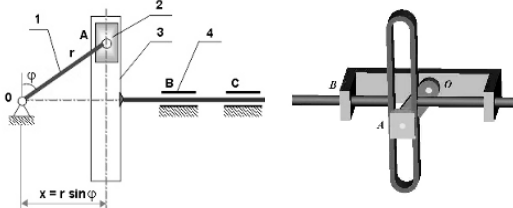
Fig. 5.

Presentation of theoretical material is illustrated by a number of Web pictures, including animated illustrations 2D-, 3D-models of mechanical objects, mechanisms in particular (Fig. 6). Animated models of mate mechanisms, ellipsograph, scotch-yoke mechanism, and link gears with swinging and rotary link, planetary gears with inner and outer catching and many others are worked out and used now.

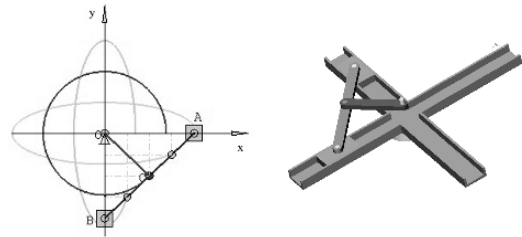
The models illustrate total cycle of mechanism movement, they are parametric and complicated.



a) Coulisse mechanism.



b) Scotch-yoke mechanism.



c) Ellipsograph.

Fig. 6. Models of mechanisms (illustrations).

Development of each model is rather labour-consuming process. Let us discuss the technology of producing 2D-, 3D-animated models of mechanisms in more detail.

A) Creation of computer animated models in mathematic packing MAPLE.

Options of MAPLE in the field of development animated graphics help to create 2D-, 3D-animated models of real mechanisms and to deduce graphical plots of parameters to time [3].

Sequence of operations for production of animated model in the environment of mathematical packing *Maple* is presented in Fig. 7.

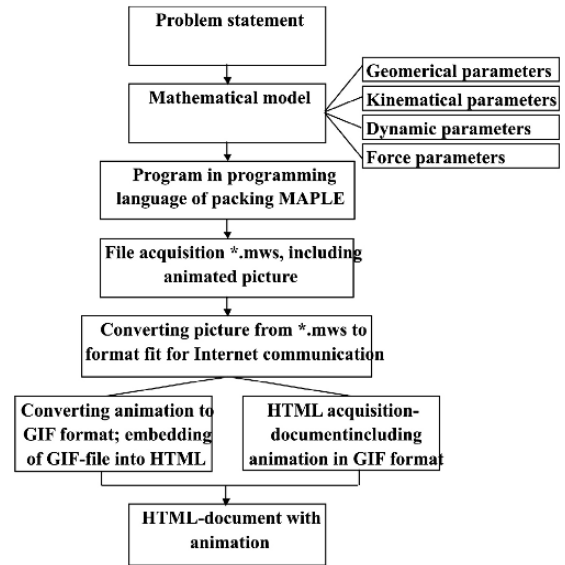


Fig. 7. Production of animated models in packing *Maple*.

1). Problem statement includes the description of input and output parameters.

2). Composition of mathematical model of mechanism: description of geometrical, kinematical, force and dynamic parameters is used depending on handling a problem:

- geometrical parameters: link dimensions, coordinates of datum points, link slopes with respect to axis;
- kinematical parameters: velocities, accelerations of datum points, angular velocities and acceleration of all links;
- force parameters: loads (single and distributed forces, moments), applied to parts of a mechanism;
- dynamic parameters: mass, force and moments of inertia.

3) A new program is being prepared on the base of a constructed mathematical model in the built-in programming language MAPLE.

Coordinates x_A, y_A, x_B, y_B of points A, B of a mechanism are defined as time functions (in the interval from 0 to T , where T - is a time period of one revolution of AB crank), and links OA and AB are set as lines with coordinates $\{(0,0), (x_A, y_A)\}$ and $\{(x_A, y_A), (x_B, y_B)\}$ accordingly and slider B - as a rectangular.

2D-model of a crank mechanism (is included in file *.mws) is the result of executed program. Some frames illustrating the position of mechanism at any instant are shown in fig. 8.

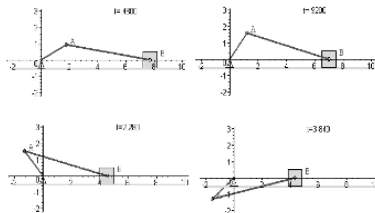


Fig. 8.

4). Converting. Manufactured model is converted into WEB-format (CIF) and is built-in into HTML-page.

B). Animated system of designing SOLID WORK together with program set DYNAMIC DESIGNER MOTION (ADAMS) is used as alternative environment of computer modeling.

Let us consider the acquisition of 3D solid model as illustration of crank mechanism.

The first stage-formation of 3D parts of a mechanism (Fig. 9, a) and it is necessary:

- a) to draw a flat sketch, made with the help of simple primitives, entering an outline;
- b) to "define" an outline (preset dimensions, correlations: parallelness, perpendicularness, concentricness, equality, etc.);
- c) to design 3D parts (outline drafting by pressing out along directive, rotating along the axis, drawing jackets, holes, bevels, etc.)

The second stage-uniting parts into assembly (Fig. 9, b) with the help of applying so called "integration" on them (conditions, coincidences, parallelness, perpendicularness, concentricness, etc.)

Limiting their relative mobility.

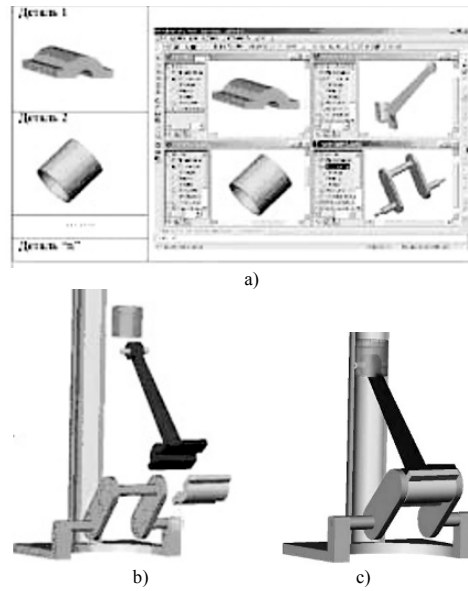


Fig. 9. Design of 3D parts.

3D solid-state parametrical model of a mechanism (Fig. 9, c) is received as a result, the model being passed to the partner systems such as: DYNAMIC DESIGNER MOTION (DDM).

The third stage-receiving an animated model in the packing DDM. In order to do it animated parameters are added to the geometrical model, worked out in SOLID WORKS: leading link is chosen, assigned a view of its movement, the number of frames of animation, time of its reproduction. It is possible to watch colored 3D of moving mechanism, design its single parts in space, and examine kinematics and dynamics on the monitor screen.

Received animated model can be kept as a demo reel (in format *.AVI) or in format *.WRL (VRLM, Virtual Reality Modeling Language) which is a standard for passing 3D virtual scripts into Internet. It gives opportunity to embed reference for them into HTML-pages and publish them in Internet.

The fourth stage- display of graphical results. Options of SOLID WORKS and DDM programs help to display designs of kinematical (link velocities and acceleration), dynamic (forces, moments) and other necessary parameters from time to the screen.

Working with such DTS the user can not only study principles of analytical solving of mechanical problems but to become skillful at computer modeling.

Operation with appendix "Tests and problems" helps to:

- learn skills in solving problem;
- exercise self-control of knowledge (local version), intermediate and final control of knowledge (distance version);
- form test tasks (subsystem "Test Constructor")

- carry out monitoring of learners' standard of knowledge.

This subsystem registers the results of tests of each learner, the number of attempts and time spent on answers.

For assessing the proficiency we use such test assignments as: "yes-no", "multivariate choice", "list regulating", "and input of one's own answer".

Appendix "Tests and problems" contains more than 300 test assignments in the sections of theoretical mechanics. At present the base of assessing proficiency is expanding.

Appendix "Laboratory manual in mechanics" contains a set of computer calculated-graphical works; each of them includes the name, aim, short theory, instructions in details for performing the tasks, condition of a problem, variants of assignments. File-samples are given to help a learner to solve standard problems on statics, kinematics and dynamics on the course of theoretical mechanics.

3) Teaching Aid.

Worked out DTS is used together with the teaching aid "Theoretical mechanics on computer". This aid is a practical manual for the work with teaching system in local and distance modes. The manual also contains solution algorithms of standard problems on mechanics in the mathematical packing MAPLE environment, description of comprehensive calculation of gears and it helps the learners study course of theoretical mechanics for technical universities independently and to solve engineer's problems on computers.

DTS on theoretical mechanics passed evaluation test in the teaching process at Astrakhan State Technical University in 2003 and it showed a good performance.

Problems of program realization were solved when developing DTS. They include the following:

- format choice with due account of their mutual compatibility and opportunity of transfer over Internet;
- choice of compliant software and realization of technological chain development of DTS;
- possibility of providing local and distance operation with appendixes;
- providing of textbook updating, adding new teaching material in particular. In the future it is presumed to develop an integral distance information environment on a mechanical type worked out on the base of DTS, an environment, where it is possible to form an integral array of knowledge elements (such as mechanics) and to realize dynamic access for reference data on various specialties.

Apart from reference and teaching theoretical material there will be provided model opportunities, control functions and administering.

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Game Playing and Systems Thinking

Thomas Hansson
University of Southern Denmark,
Institute of Philosophy,
Pedagogy and Religious Studies,
Engstien 1, 6000 Kolding, DK,
hansson@ifpr.sdu.dk

Abstract: A lot of the literature builds on a theory of communication that focuses on text contents and interactive learning. But in order to improve teaching and learning we need to understand why students communicate the way they do. In order to do so, research needs to begin with the actual process by which textual messages are produced. Then we can analyse the form and contents of the messages. The shift of focus from text products to working processes is a matter of didactic design. This chapter outlines the teachers' didactic designs and the students' verbal exchanges on a virtual platform. More specifically, what would be the characteristics of emerging patterns of interaction produced by ICT and social communication systems?

I. INTRODUCTION

It is important that schools provide the necessary tools for the students' learning, be it books, tape recorders or computers. It is also important that schools adjust to the students' needs and organise instruction, cooperation and self-guided work so as to motivate learning. 'Systems thinking' for controlling student behaviour have produced much innovative modelling, some respectable instrumentation, but little empirical theory-testing. Rather than following a traditional division between abstract conceptualisation and pragmatic use of media for language learning, this chapter outlines an experimental simulation-stimulation setting where didactic designs explore the students' opportunities for learning. Pre-designed technology and activity systems enable self-organisation, group control and

adaptation to an interactive discourse for language learning.

Properly designed research and development create user involvement between teachers and students. A number of Nordic project designs have enabled interactive real-life activities for dialogical exchanges, learning processes and emerging knowledge. Focus of the referred studies has been on (a) design of an interactive virtual environment and (b) exploration of the functioning of communicative competence inside and between social systems of secondary school students. The purpose of the studies has been to investigate the actual means by which didactic principles of collective production become operational for the teachers and motivational for the students.

II. BACKGROUND

Education is a global concern. It is crucial for humanistic information sciences to study, review and assess the impact of ICT in Kindergarten, schools, universities and knowledge society. It is also crucial for research and practice to study the effects of software and the way learning develops in computer-mediated communication. One contention is that man exists in a reciprocal relation, i.e. in the completeness of an interactive bond between *Self* and *Other*. Another contention is that individual and collective learning [1] form complementary processes. Education is a fundamental inter-human activity regardless if the context is play, family or work.

III. PREVIOUS RESEARCH

People perceive of ICT-media differently. Among educators, the media are considered

to be either great fun, educationally safe or morally harmful. Critics [2] say ICT is “a marginal force” in education, suggesting [3] an encompassing perspective, “If the role of the computer is so slight that the rest (other classroom variables, *author’s comment*) can be kept constant, it will also be too slight for much to come of it.” An implication of the quote is that, for the sustainability of ICT, teachers need to learn to integrate class- and computer room activities plus stimulate interaction. On the other hand, [4] and [5] argue that virtual learning is an imperative for students as they respond so well to the medium. Based on a variety of opinions as to the usefulness of ICT in education, this text opts for an in-depth analysis of didactic designs for strengthening relational competences.

Word-processing/process writing is a familiar phenomenon and today the use of mediating instruments carries implications for learning, development and even life processes. Young people’s ability to operate the technology is based on individual and collective processes for managing social systems by natural language - be it for traditional schooling by pencil, for entertainment by TV or for fun by computer games. Mediation of meaning helps the students combine semantic what-contents, pragmatic how-behaviour and perhaps even citizenship. Long ago, reference [6] (p. 104) formed the hypothesis that: “Human development is facilitated through interaction with persons who occupy a variety of roles and through participation in an ever-broadening role repertoire.” This article verifies to the given contention.

But regardless if for role-identification or other, any historical, social or cultural manifestation of a shared activity brings learning and hence social development into operation. The ambition for a series of Nordic studies into ICT and language learning is for the teacher-researcher to design shared web- and classroom based activities as a congenial context for improved teaching and learning

practices. By operating digital media for learning, the students find their way in the world, provided they muster the necessary commitment, enjoy communicating with others and find the time to reflect over the relation between abstract-symbolic sign systems, signifying the way the perceive of interactive role playing and real world relations as classmates.

In spite of a hoard of innovative approaches to teaching and learning, computer games are as handicapped as teachers for relating between the students’ artificial classroom context and the real world of personal relations. Reference [7] says that people misunderstand the nature of authentic activities, asking, “How can (classroom *author’s comment*) simulations be authentic when by the very nature they are artificial - still a simulation.” Handicapped as they are by institutional restraints, many educators use traditional methods in their attempts to re-enact the real world inside the confines of the classroom.

IV. THEORY

Research and development on didactically organized social systems forms a multi-dimensional field of practical investigation, theoretical justification and creative presentation. Long before the emergence of a theory of ‘learning organizations’, reference [8] introduced a rainbow coalition of general systems theory, cybernetics, information theory, computation and control. At the heart of the construct lies a definition suggesting a relationally organized unit of analysis.

A whole which functions as a whole by virtue of the independence of its parts is called a system, and the method which aims at discovering how this is brought about [...] seeks to classify systems by the way their components are organized (interrelated) and to derive the ‘laws’ or typical patterns of behaviour, for the different classes of systems singled out by the taxonomy.

An implicit understanding of Buckley's definition suggests that the operations of a social system materialize as dialogic language 'games' between narrowly defined borders, expressing sender/receiver intensions categorized by process control, feed forward and feedback loops.

According to [9], *cybernetics* is a useful theory for explaining the functioning of social control systems, i.e. how students react to teacher-created didactic designs. Relevant socio-cybernetic perspectives include process components related to the following questions: *What do social systems consist of* (individuals, actors, medium), *How do social systems change* (planning, control, contradiction) and *What are the consequences of the self-referentiality of social systems* (prognosis, credibility, fulfilment)?

Reference [10] separates between a *first* cybernetics defined as a deviation-counteracting network of properties and relations for reaching static balance by means of *negative feedback*. In some of the studied contexts, feedback is provided between elements made up of individual *I-It* utterances, i.e. typically boys who fail to adhere to the ethical rules of a web-based community of practitioners. Regulation by negative feedback loops brings status quo into place, a situation of little interest for an expanding experimental school design on the workings of a social system.

However, Maruyama also defines a *second* social cybernetics for amplifying mutual relationships, for example between Nordic students, by means of *positive feedback* loops between interlocutors who respond to an initial impetus that inspires positive action and creative deviation from an initial condition, e.g. the features of a digital medium supported by *I-Thou* adaptation through social-communicative competence rather than technical computer efficacy. During the dynamic *I-Thou* process, some feedback loops amplify and others counteract generic change and systems development. Positive feedback loops seem to inspire deviation from a

conventionally agreed language norm. As a result, heterogeneity (dynamic differences) increases, new structures develop and the amount of shared information grows. The process forms a basis for understanding the collected data as "dialogical feedback regulation". It brings the expansive aspects of the virtual and social language game into play.

Descriptions of interactive, praxis-oriented ICT-field study approaches to research and development emphasise contextual learning. They build on the fact that people are physically situated in a concrete setting, registering, perceiving, reflecting and/or (re) acting on human input, feedback or response. In relating previous research to development of theory, we need to specify both individual learning and the research objective, which is to plan-manage-test the functioning of a didactic design. The specification contains actors (referents) and their relations (arguments) to the world and to other people. Old-school research focused on de-contextualised teacher relations to subject contents and students. At best they explored the functioning of (a) a professional subject relation and (b) a social student relation. In a preferred 'theory' we opt for a focus on (c) the teachers' ability to act on the students' relation to the taught, studied and learnt contents. Fig. 1 contains the arguments and referents for de-contextualised learning.

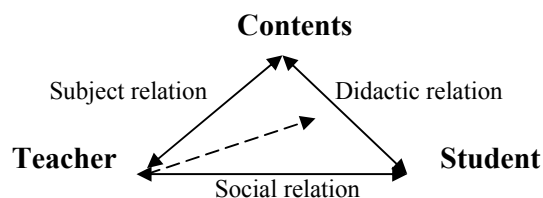


Figure 1. 'Didactic Triangle' for De-contextualised Teaching and Learning

Fig. 1 fails to account for contextual learning. As the practitioner-learner always seek an interlocutor, we might just as well admit to an ethical dilemma accompanied by a normative mission in educational

research. We may also argue in favour of a participatory approach to cooperation between the university and local schools because synergetic effect, spin off and growth are so obvious. The overall problem, however, seems to be that that currently deployed methods, discourses and typologies fail to acknowledge the ethical impact of Didactics in the design of systemic and contextualised teaching-studying-learning practices.

V. THE ETHICS OF LEARNING

As to the ethical aspects of the design, 'interbeing' was first coined by a Bhuddist monk, then re-installed [11] in later approaches. Now inter-being describes a fundamental reality of a life world reality where "things do not exist separately and outside each other." Martin Buber's [12] 'dialogical philosophy of knowledge' comprises of *I-Thou/I-It* relations, providing the theoretical underpinnings for understanding socially constructed meanings of human behaviour. Buber's original concept, 'inter-human' (*Zwischenmenschliche*) focuses on a narrowly defined scope of relations signifying the 'space' between *I-Thou-It* conceptions. Inter-human exchanges function optimally when people meet physically or mediate their thoughts, i.e. their intentions as/by time-place congenial speech. Web-based mediation by technical tools and symbolic communication makes it both harder and easier for students to enter 'interbeing' relations with what is unique and important. This makes it necessary to define the components and functions of studied interactions enabled by mediation in a digital medium. The process is to be understood as an acknowledged [13] operation within *I/Self*. It is also to be understood as an external process with *Thou/Other* identified by the interlocutors' positioning within a self-regulating activity system. *Internal mediation* operates through conventional signs like letters or symbols. *External mediation* operates through cybernetic or balance-seeking

feedback loops between students and teachers committed to social construction of meaning, intentions or *I/Self* and *Thou/Other* relations with/between the student groups.

The result of mediating operations is improved higher psychological functions for the learner. Some relations are counter-productive to learning and others are educationally valid-good for the formation of activity, awareness and personality in the students.

VI. THE RESEARCHED CONTEXT

In order to understand the student's relation to the taught and learnt contents, the university students, teachers and researchers plus classroom teachers of a Nordic project carried out work with 11-13 year old students. A number of university organised studies hosted students at local schools in a network called *Teaching and Learning of English as a Foreign Language (TALE) Nordplus 890/2001-2003*.

The studies had some characteristics in common: The *first phase* usually meant that the students learnt the technology. The challenge for the teachers was to tell the ICT-advanced students help the weak ones. The advantage was that the students got hands-on experience of the software. Clear rules and division of labour (instructor, secretary, team worker etc) proved useful. Most of the time, ordinary school equipment in computer rooms or libraries, Internet etc were good. However, where portable computers were used, technical difficulties caused problems. The *second phase* meant that the class teacher organised the subject contents for the students'. Now the challenge was to involve the students in the decision-making process. They typically chose *Harry Potter*, *Christmas*, *Superman* or *old Castle* themes. Then the class teachers integrated classroom work (maps, books, dictionaries) with computer room sessions (work in pairs, graphics, text composing). The challenge during this phase was to organise co-operation with the university so that

both parties could influence the final design. The benefit was that the students' motivation remained at a high level. One facility to be successfully implemented during this *third phase* was a reflective text medium (web log) called *Blogger*. The challenge was to technically learn to operate it. The benefit was that we could take care of the reflective side of text composing. During the *fourth phase* the class teacher planned interactions between the students. They usually responded well to the overall (classroom-computer room integration and software facilities) design. Finally, during the *fifth phase* the class teacher co-ordinated exchanges with neighbouring or foreign schools. Merely practical difficulties like equipment compatibility, feedback plus starting/ending times posed a challenge. Again, the benefits were substantial in terms of student motivation.

VII. POTENTIAL FOR LEARNING

The software, students and teachers make up the major components of a virtual didactic for collective learning. First of all, computer-media like *SimCity*, *Civilisation* and *SimEarth* allow for high levels of user control, pursuit of intention and choice of strategy. *ActiveWorlds* is a similar medium designed for stimulating and observing co-operation and problem solving. It is a multi-player game for *collaborative construction* of the world, of knowledge and of identity. The software outscored strategy games, combat games or multiple-choice designs because the latter inspires *individual consumption* of pre-defined means for entertainment. In order to investigate levels of self-control – a prerequisite for dialogue – we need to explore the relation between socio-cultural construction of the world and web-based experiences for students. Thus we may understand the human mind in an interactive context of individual *Self* (subjects/agents) exploring a world of objects/artefacts/people (*Other*).

As to the chosen software, Buber [13] says that man strongly desires to enter a personal relation with artefacts like computers, software and graphics and to imprint on them a unique *I-Thou-It-We* relation: “To use them, even to possess them, is not enough, they must become his in another way, by imparting to them in the picture-sign his relation to them.”

The ambition to increase human purposefulness and active participation is an ongoing process for research, education and similar systemic practices. The purpose of introducing, managing and evaluating a digital medium for learning in a structured social system, is to explore the actual means that stimulate learners to participate in an “interactive learning activity” [14]. This ambition applies equally for exploration of the teachers' ability to benefit from life-long learning and the students' ability to learn English as a foreign language.

We implemented *ActiveWorlds* as a digital medium for learning through interaction, movement and construction between ‘normal’ students in municipal secondary schools. The deployed didactic design marked a shift in the traditional methodology for helping English teachers use digital media. Completed studies (pilot, comparative, university/local school, and English subject) were launched in an ambition to strengthen user involvement (ownership, sustainability) on a digital medium for learning.

Teachers usually stick to familiar classroom methods and objectives. This is the project teachers' preferred order of activities - before the project began: *Written English, technical software, literary genre, Pedagogical, social and moral objectives*. The students practiced those competencies, but prioritised differently: *Social, software and technical skills* first and *language-grammar* skills last. The students would have preferred to spend more time on social-constructive production of identity understood as innate self-realization than was the case: *And it's a*

new way of learning things; It was fun to make houses and it was nice to talk to friends; To visit some other world to see their world and write to them; Ist fun to work with someone you d'nt know; It was fun to put furniture in a romm cause I could decide how it should look; It was exciting to worked together with other pupls (frindes); Learn to send messages on English; to talk to your friends on the chat; Building together and communicate english. The motivational aspects of learning include qualities described by the students as *new, fun, exciting, talking, learning and togetherness.*

VIII. FINDINGS

The results apply for local contexts of schooling, thus providing actionable knowledge for teachers who operate in/on similar contexts, age group and language proficiency. A local theory about learning accounts for how the teacher-researcher (a) chooses a platform for interaction, (b) organises integration between computer room and classroom activities and (c) facilitates verbal dialogical exchanges - by means of assignments between web-based students.

A. Relation-Building and Problem Solving

In engaging in virtual communication, the project students may either communicate in the chat forum where everybody sees what they say, or exclusively ‘whisper’ to a specific *Other*.

Process control, feedback and output make up the soft cybernetic relation building operations. The design of a comparative inter-cultural (DK-FI-IS) study between Nordic partner schools posed an opportunity to understand how teaching and learning is facilitated on a virtual platform. The fact that the students learnt to operate the software provided research with a closed context. But the characteristics of the ‘bounded’ system raised some questions weather learning *per se* equals collective verbal practice and/or socio-cultural construction of knowledge

The context for learning is defined by communicative ‘building’ processes in the graphical (400 m x 400 m) *ActiveWorlds*. So is the emerging generic dialogue between the students. Find a screen shot displaying boys on snowmobiles trying to find out where to build: *Why not; We are building; Well ok come to Stone Island and visit me; ok*

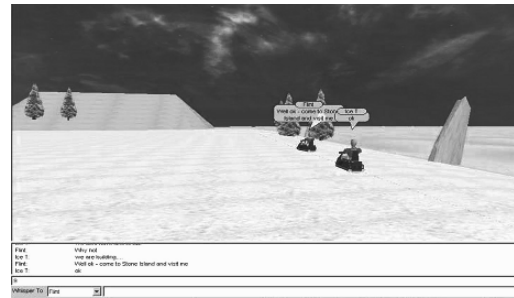


Figure 2. *ActiveWorlds* Screen Shot

Written and graphical interactions enable research to focus on the impact of the dialogical relation between *Self* and *Other* during ‘building’, moving about and text chat (role playing) operations. It would be useful to learn how different objectives-intentions-causes affect the students’ peer relationships, be they virtual or real. Could research explain cybernetic [15] double-bind learning functions? Clearly, the students’ self reflection is as important as is their direct, blunt and intuitive actions on the screen. How could an action-reflection dichotomy explain communicative control, interactive feedback and collective outcomes? Admittedly, there is one kind of conclusion to be drawn from shared ‘building’ operations. And there is another kind of conclusion to be drawn from reflective text composing in the Blog.

B. Conventionalised Greeting Procedure

Regardless of context (classroom questions and answers, diary composing, chat interaction or homework essays) people confirm each other by internalising-seeing and externalising-verifying uniqueness and wholeness in each other. *Pon Da Replay* contributes to the success of ‘her’ social

system at *Dyrehaveskolen* by being positively proactive in supplying inspirational initiatives to her virtual team. She also takes her time to read what the others say. Throughout the computer room session, she remains committed to positive relation building with her classmates and instrumental building in their shared world. Initially, the team sees, greets and acknowledges each other, signalling that everybody is OK. Eventually, this extensive procedure proved a valid contributor to their social system. Just like in any human encounter, initial entries help the girls form a potentially dialogical unit: *Hallo; hello; welcome; Are you ready for some guest??; yes; elloo who is there; hey Jessica; hej chloe; HEY; hey stinne* Successful interlocutors realize the uniqueness in *Self* through their relations to *Other*. The conclusion is that, if properly applied, ICT-technology reinforces the sense of mediation between *Self/I* and *Other/Thou*.

C. Instrumental Project Work

It is necessary to separate between the use of a platform for personal consumption of information or the application of software for collective production of knowledge. The software offers an interface where the students graphically meet and verbally interact. When individuals in a social activity system relate to each other a dynamics emerge from their communicative verbal content and from their instrumental graphic ‘building’ actions. In another study, six 8th grade students at *Eltang centralskole* (DK), *Yhtenäiskoulu* (FI) and *Hrafnagilsskóli* (IS) made up the trans-national group, actually a (multi-)context embedded social system.

A ‘first encounter’ chat describes an episode when a Finnish student has logged on to the digital medium ahead of his peers. The instructor *Charlie* is also online, mistakenly assuming the lesson has already started. In spite of the uncertain context, positive loops help the boys’ uphold continuity in *I-Thou* exchanges of intention, meaning and information. Notice their

instrumental, project-oriented and problem-solving approach. Contrary to a the girls’ team it is hard to find social bonding mechanisms in the boys’ interaction, except perhaps for two ‘smilies’ (:D). (PC= Process control; FF= Feed forward; FB= Feedback)

(PC) Charlie: *just follow me fin*

(FF) Charlie: *we fly:D*

(FB) K of Fin: *but the lesson hasnt started in our school yet*

(PC) Charlie: *ahh but we start now:D*

(FB) K of Fin: *do i have to follow you orders?*

(FF) Charlie: *yes*

For this case, didactic design efforts led to virtually mediated individual *actions* in the students. But the design was less successful in supporting collaborative *We-activity* in the cross-national teams. The design was also less successful in including a cognitive feedback link from ‘inside’ avatars who were supposed to help freeing the students from traditional understanding of storyline rules, narrative constraints and text composing traditions.

For this study, teacher assignments and peer instructions had a positive effect on interactions. Motivation was high throughout and distant identification worked out fine. Task-controlled ‘building’ was popular, division of labour was effective and the students’ self-esteem increased - both socially as communicators and technically as graphical builders-designers.

D. Extended Co-operation

Identifying communication in *ActiveWorlds* is a straightforward business as it is easy to see who is communicating with whom. But inter-cultural negotiation makes the constraining complexity of the virtual-physical and text-action context hard to handle. Sometimes this leads to frustration between the students. They use capital letters, emphasising the importance of exploring the expressive potential of the

restricted text medium. As to the contents and style of the chat log, a project-oriented team's building-working-learning exchange illustrates a positive cybernetic feed forward loop.

(PC) Charlie: *else you can build the Garden bigger...!*
 (FB) K of Ice: *hi*
 (FB) Charlie: *hæ*
 (FF) K of Ice: *we are here what can we do*

The beauty of the mediating technology lies in the resource to register simultaneous conversations. As every instruction-greeting-response-question etc is recorded in the chat log, the teacher can evaluate the students' individual progress. The log also makes it easy for the teacher to re-design dysfunctional collective systems or intervene when things go wrong.

E. Happy-End Example

In developing a social cybernetic, some characteristics are more obvious than others. Reference [16] emphasises the purpose of the system, the specifications, the functions, the components and the relational integration. Genuine, mutual and dialogical interaction has a formative effect on social systems. Traditionally, didactic design measures for organising the students' work take the teachers' regulation and control for granted. Needless to say, the students prefer a 'soft' form of control.

Project data on a verbal-graphic exchange between *Charlie* and *Knight of Fin* describes a *negative* loop, because the effect is disappointment, lack of co-ordination and withdrawal from 'building' activities. But *Knight of Fin* ignores *Charlie's* instructions and repeats his question. In the end *Charlie* 'shouts' at *Knight of Fin* in order to make him react. When *Knight of Fin* returns from the textual chat-medium to the virtual 'build-and move about' mode, their working relationship is re-established. *Positive* feedback is eventually shared. *Charlie*

coaches *Knight of Fin* who adheres to his pieces of advice. *Charlie* even extends the relationship by asking for a complementary communication system to maintain future interactions.

(FF) K of Fin: *well...??*
 (PC) Charlie: *here are the garden take some flower and copy the codes..!! and then follow me*
 (PC) Charlie: *have you copi some af the codes*
 (FB) K of Fin: *ok i'm done*
 (PC) Charlie: *follow*
 (FB) K of Fin: *yes*
 (FF) Charlie: *have you MSN*

Charlie's communicative ability as demonstrated by *positive* feedback loops in a soft cybernetic for peer learning - plays a significant part in the exchange of ideas, intentions and instructions. Both interlocutors display committed and goal directed textual and virtual quality in their operations. As a result they build-decorate a graphical garden with virtual trees, flowers and a fence. *Charlie* and *Knight of Fin* find their 'game playing' instructions and problem-solving exercises useful. Their language and social-constructivist identification of a productive social system develops positively. Even though the dialogue fails at times, they uphold a creative attitude towards each other. The example supports the idea that, contrary to what people assume, young Internet users seek opportunities for communication rather than technological brilliance.

IX. CONCLUSION

A systemic design for research and development enabled analysis of ICT-mediated *action system* of individual reactive subjects. The design allowed for verification of the impact of dialogue, but failed to achieve the grand objective of producing sustainable *activity systems* in the participating schools, i.e. collective work with a shared objective in mind. Very

few facilities in the *technical system* support interaction by instruction-feedback-control in the designed *social system* of individual students. The combination of building and chatting made it possible for the students to participate in dynamic interaction, thus defining a *socially mediating system* by mutual *I-Thou/I-It* control. In order to become productive, the system must host-include-account for 'feedback loops' between instructors and peers and between class- and computer room settings.

The opportunity for research to explore such contexts seems limitless. There are endless relations between designs, artefacts and people to study. A didactic design method for balancing-integrating the pragmatics of a mediating system and for developing creative feedback loops between interlocutors form the specific suggestions for future research.

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Research on Maintainability and Expansibility of E-Learning Systems

X.W. Hao, X.X. Meng, X.Cui

School of Computer Science and Technology, Shandong University, Jinan 250100, China
{hxw, mxx}@sdu.edu.cn

Abstract—Web based E-learning system is by nature a multi-layer structured web application. It is composed of a main directory in web server which includes sub-directories, virtual directories, a large amount of documents and databases, all of which constitute the educational resources of the E-learning system. In the traditional E-learning system, educational resources are often organized statically in specific coursewares. Due to the characteristics of web application itself, updates in course contents may lead to great changes in document positions and hyperlinks, thus resulting poor maintainability and expansibility of E-learning systems. This paper proposed a knowledge point based metadata model of educational resources, through which the changes in course contents could be altered logically via directory structures of the course, without direct change of the contents of web pages, hence enhancing the maintainability and expansibility of E-learning systems. Based on this research, an educational resources content management system supporting this model was designed and implemented.

I. INTRODUCTION

With the rapid development of knowledge society and the accelerating of knowledge updates, E-learning has now become a very important means of learning. More and more people receive education and update their knowledge through E-learning[1]. E-learning system, especially web-based E-learning system is by nature a multi-layer structured web application. It is composed of a main directory in web server which includes sub-directories, virtual directories, a large amount of documents and databases, all of which constitute the educational resources of the E-learning system. In the traditional E-learning system, educational resources are often

organized statically in specific coursewares. Due to the characteristics of web application itself, updates in course contents may lead to great changes in document positions and hyperlinks, thus resulting in poor maintainability and expansibility of E-learning systems. With the development of E-learning system, as time goes on, the quantity of data in E-learning increase rapidly. Meanwhile, the types of educational resources are more various, with web pages, ppt documents, images, animations, videos becoming important educational resources. The maintainability and expansibility of E-learning system become key problems to be studied and solved in E-learning applications.

II. EDUCATIONAL TECHNOLOGY STANDARDS AND RELATED RESEARCH

Educational technology standards are the vital measure to ensure the sharing of educational resources and the interoperability among systems, and the sharing, reuse and interoperability of educational resources are decisive to the practicality and economy of E-learning system. So many enterprises and science organizations all over the world have began the research on educational technology, and many standards or specifications have been issued.

A. Main Educational Technology Standards

The American Aviation Industry CBT Committee(AICC), established in 1988, is in charge of constitution of standards for CBT and related technological training. They set down a series of AGRs (AICC Guidelines & Recommendations) specifications in different fields, among which AGR-006 (document-based CMI system) and AGR-010 (Web-based

CMI system) are primary. CMI (Computer Management Instruction) prescribed issues of interoperability among computer management systems, including moving courses, CMI communication and students' data storing.

The US Defense Ministry Advanced Distributed Learning Organization(ADL) proposed a sharable content object reference model(SCORM) [2]. It defined the web based learning contents aggregation model and the learning objects Run-time Environment, which primarily aimed at enabling the courses to transfer from one platform to another, to create repurposed component for different courses to share, and to retrieve course materials rapidly and accurately.

Instructional Management System Global Learning Consortium(IMS) was originally a project group under EDUCOM (now as EDUCAUSE), which was a non-profit institute of the USA Higher Education Association. Now IMS has developed into Instructional Management System Global Learning Consortium, Inc [3]. IMS include a series of acknowledgement and markup specifications, and some common parameters tracing learning process, for example, meta data, content packaging, problem and test interoperability, learners' information packaging. At present, many standards, such as IEEE / LTSC and SCORM, have cited the specification documents of IMS.

Besides, Learning Technology Standards Committee (LTSC) of IEEE also issued related standards for learning technology [4]. The standards include five aspects: general specification, learners, learning content, data and metadata, management system and application software, all of which constitute the body of IEEE 1484. Many LTSC specifications will be set as an international standards by ISO / SC 36. International Standards Organization (ISO) established a Joint Technical Committee 1 (JTC1 / SC 36), engaging in collecting, updating, and approving of specifications for learning, educational and training technology. Their main research projects include architecture of network education, metadata standards of learning resources, terminology in network education, and related technology of collaborative learning. At present, there are seven different work groups: WG1(Vocabulary), WG2 (Collaborative Technology), WG3 (Participant Information), WG4 (Management & Delivery), WG5 (QA & Desc. Frameworks), WG6 (Int'l Standardized

Profiles), WG7 (Culture, Language, and Human Functioning Activities) [6].

The main goal of learning technology standards is to ensure sharing of learning resources and interoperability between different E-learning systems. In the management and usage of learning resources in an E-learning system, especially in the body of knowledge, the relationships between knowledge and learning objects, learning resources re-construction, there is still lack in in-depth study by now.

B. *E-learning and LCMS*

With the wide application of E-learning systems, the amounts of learning resources are increasing rapidly and the types of LOs are much more various than before. As years go by, more and more time have to be spent in retrieving education materials, thus a plenty of valuable resources can not be fully employed. Therefore, to implement content management for educational resources has now become a very important issue in the study of E-learning[9,10].

Up to date, more and more researchers have realized the importance of content management in an E-learning system. Norman have implemented a content management system in an adaptive learning environment[8], which aggregated many types of multimedia learning resources by SMIL. A SCORM system tries to re-organize the original learning objects, so that the LOs can be reused by the teachers[9]. J.H. Yang, N.W.Y. Shao also made a discussion of the content management in adaptive learning environment[11]. In addition, education project Eduforge has set up a Learning Content Management System(LCMS)Topic to probe into the ideas, the technologies and the implementations of education resource content management.[12]

III. COURSES KNOWLEDGE BODY AND LEARNING OBJECTS

The courses knowledge body refers to the knowledge set which learners should master for some specific goals. It is a main component of E-learning system. The body of knowledge can be divided into a series of knowledge units, and a knowledge unit can be further divided into knowledge points.

Knowledge points are the smallest knowledge units in

the body of knowledge of a course, and we can explain them via various medium, for instance, ppts, graphs/images, animations, videos, or audios, all of which can be called learning objects. The combination of knowledge points makes up a knowledge unit, which corresponds to a web page. That is to say, there are one or more knowledge points in a knowledge unit in correspondence with different learning objects. A knowledge unit can also nest another knowledge unit.

A. Knowledge Point based Learning Object metadata model

In E-learning, all learning resources are stored in different type of data files, which are collectively called learning objects(LOs). Learning objects are the carrier of knowledge, that is to say, knowledge points can be explained through LOs. A metadata model of LO was proposed in SCORM[2], which is used to share learning resources. But it has no knowledge information about LO itself.

In order to set up a relation between the body of knowledge and learning objects, on the foundation of SCORM standards and Dublin Core metadata, we proposed a new framework for LO, which is illustrated in Fig.1.

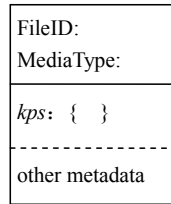


Fig.1. LO Framework

In the framework of a learning object, “FileID” means the data file identifier of the learning object; “MediaType” means the type of the learning object data file, which include text file(web page file,pdf file and ppt file etc.) , graph or image file, animation file, video file or audio file; “kps “means the knowledge points set carried in the learning object. Other SCORM and Dublin Core metadata can also be included if necessary.

B. The m:n Relationship between Learning Objects and Knowledge Points

Every knowledge unit corresponds to a Web page in E-learning system. Knowledge units includes knowledge points, and knowledge points correspond to different learning objects. Therefore, between knowledge points (constitute to KUs, i.e Web pages) and learning objects, there is a m:n

relationship, as illustrated in Fig. 2.

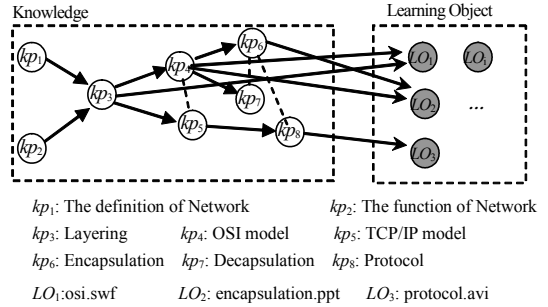


Fig.2. an Example of the Mapping relationship between knowledge points and learning objects

In Fig. 2, the left show the knowledge points, which make up a knowledge unit. The right listed learning objects. One learning object can explain one or more knowledge points, meanwhile, one knowledge point can be explained by one or more learning objects, hence forming m:n mapping relationship between knowledge points and learning objects.

IV. EDUCATIONAL RESOURCES CONTENT MANAGEMENT FOR MAINTENANCE

According to m:n mapping relationship between knowledge points and learning objects, combined with related standards of SCORM model and the like, we designed a educational resource content management system, so as to enhance the maintainability and expansibility of E-learning system.

A. System Architecture

The educational resource content management system can be divided into three layers. The first layer is educational resources media layer (learning objects layer), composed of various learning objects data files. The second layer is learning object metadata layer, expressing the logic structure of the mapping relationship between the body of knowledge and the learning objects. The third layer is the body of knowledge in a course, which is the knowledge that E-learning should explain. The architecture is illustrated as in Fig. 3.

In the architecture, the metadata of learning objects not

only include its physical description, but also include its knowledge description through knowledge points, which can be used for retrieving and dynamic utilization of learning objects. In addition, metadata reflect successfully the corresponding relationship between learning objects and the body of knowledge of the course. Hence the maintainability and expansibility is improved.

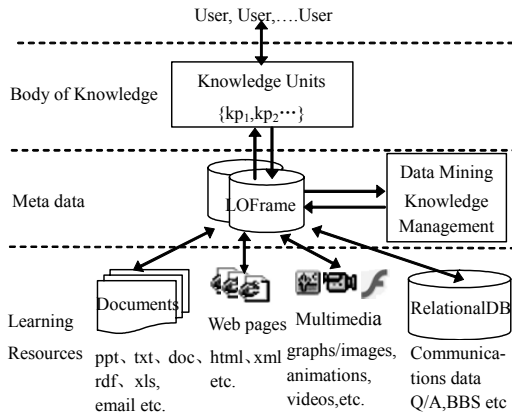


Fig.3 Architecture of the education resource content management system.

B. Maintenance of Courses Knowledge Body and LOs Repository

The main functions of Educational Resources Content Management System (ECMS) include the construction and management of body of knowledge, the management of metadata of learning objects knowledge framework and the mapping engine of learning objects. Fig 4 shows the interface of knowledge framework construction and management.

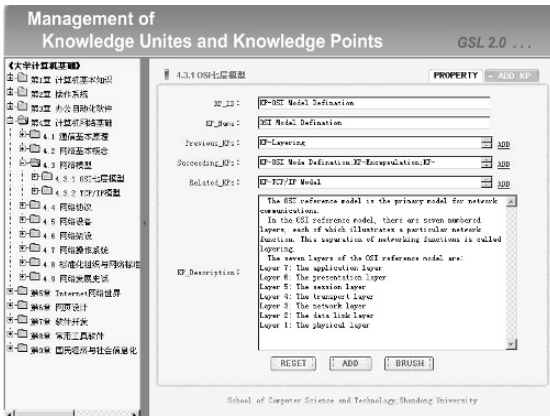


Fig. 4. Knowledge framework construction and management

The left pane is the tree structure of knowledge units, which is referred to as course directory tree. The right pane is the area for defining knowledge points and constructing the knowledge network. Changes in course contents can be realized by adding nodes, deleting nodes or updating the knowledge points set contained in the nodes. The updates of course contents, the adding, deleting, and updating of learning resources are relatively independent, thus ensuring the expansibility of E-learning systems.

Fig.5 shows the interface of the management of metadata of learning objects.

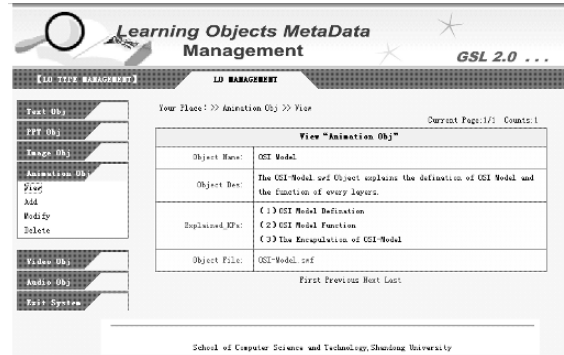


Fig.5. Management of metadata of learning objects knowledge framework

The type of learning objects can be added or removed in the left pane, and in the right pane, a new LO can be added to the LOs repository and the metadata of the learning object can be edited here, which include the knowledge points the LO is designed to explain.

V. CONCLUSION

In conclusion, the idea of implementing content management in an E-learning system and constructing framework structure for learning objects provided an efficient solution to the relationship between the body of knowledge and the education resources hence enhanced the maintainability and expansibility of E-learning system. In addition, the learning objects can be shared and re-constructed in other courses and even other E-learning systems.

ACKNOWLEDGMENT

We would like to express our thanks to the author's graduates, Yaofeng Chang and Xu Cui, who have helped do lots of programming work in GSL.

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Research on Web-Based Self-Learning

X.W. Hao, X.X. Meng

School of Computer Science and Technology, Shandong University, Jinan 250100, China

{hwx, mxx}@sdu.edu.cn

Abstract-E-learning has now become a very important education mode, and various E-learning systems and prototypes have been developed. In knowledge society, updates of knowledge is accelerating, continuing education and lifelong learning has accordingly emerged. As a solution to these new education forms, we proposed a novel E-learning mode, i.e. web-based self-learning. In this paper, we first analyzed the differences among self-learning and other E-learning modes(such as CSCL etc). Then, we give more detailed discusses about a self-learning environment, such as characteristics of learners, learning contents, learning objectives and learning theories, and made further researches on the organization and management of learning resources. At last, we described briefly our self-learning system prototype GSL.

I. INTRODUCTION

Learning is the process of acquiring knowledge and skills from reading, listening, studying or practicing. With the development of computer technologies, many computer aided instruction(CAI) methods have been occurred, e.g., computer-based training(CBT),web-based training(WBT) and many other computer aided instruction systems. In recent years, with the rapid development and the popularization of multimedia, computer network and the Internet, computer network-based, electronic, digital and multimedia computer aided education, which is referred to by E-learning, has grown rapidly. More and more universities, educational organizations and enterprises have established or are building their E-learning systems. Different from traditional computer aided instruction systems, modern E-learning systems emphasize distributed learning, sharing of educational resources and communications among learners. E-learning has enabled more and more people to receive their needed education,

breaking the limitation of time and distance. E-learning has now become one of the most important applications of Internet[1].

II. LEARNING THEORIES AND RELATED WORK

Traditional learning can be divided into two different modes: class learning mode and individual learning mode. Class learning mode is a typical mode of face to face instruction, in which teachers set up educational objectives for students and design the learning process(i.e. instructional design), to all learners, the learning contents and learning process are all the same. So it is a teacher-centered learning mode. On the contrary, individual learning mode is a student-centered mode that needs the learners to make their own learning goals and arrange their own learning process. In traditional learning, there are many different learning theories, such as behaviorism learning theory, cognitive learning theory and constructivism learning theory [2,3]. They all intend to reveal the nature of learning, so as to improve the effects of learning, transmit knowledge more efficiently and foster the various needed talents.

In recent years, E-learning systems have been developing rapidly. In the research and application of E-learning systems, researchers have proposed many concepts, including computer supported collaborative learning(CSCL), adaptive learning, personalized learning etc. It is clear that all the E-learning systems are the implementation of the traditional class learning in computer network.

A. Computer Supported Collaborative Learning

Computer supported collaborative learning(CSCL) is developed from collaborative learning theory. Collaborative learning refers to an instruction method in which students at

various performance levels work together in small groups toward a common goal. The students are responsible for one another's learning as well as their own. Thus, the success of one student helps other students to be successful. CSCL is a mixture learning mode of learning theories ,computer supported collaborative work(CSCW) and learning technologies. It emphasizes the communicational activities among learners. In the support of computer networks, the learners themselves or the learners and the teachers can make synchronous(e.g. online chatting, instant message) and asynchronous communication (e.g. BBS,Q/A or Email), and also they can make collaborative virtual lab or some other learning activities.

The field of CSCL is fruitful, with many prototypes and application systems having been developed. From the perspective of a distributed computing environment, Suthers proposed four different architectures of CSCL, which include: centralized architecture, replicated architecture, distributed architecture and hybrid architecture[4]. Through the knowledge awareness , Sharlok System can provide a list of learners with similar behavior and interest , which permits one learner to invite others for a discussion about some issue, and thus a collaborative learning relationship can be set up[5]. CVW is a collaborative virtual workspace, which includes online chatting and presence awareness system to support the communications among learners[6].

The nature of CSCL is to set up a network environment to provide a method of communication among learners, so in the research of CSCL the flexible communication means is the focus.

B. Personalized Learning

Personalized learning is a personalized-based unique learning mode reflecting differences in learners. Personalized learning has always been the most active research issues in E-learning these recent years. In E-learning, they emphasize individual differences, such as capacities, learning background, learning styles, learning objectives, and the changing states of individual knowledge in learning process. So E-learning in these trends attempt to provide a personalized or adaptive learning process [7].

Personalized learning mainly includes personalized learning

materials, personalized learning objectives and personalized learning process. In E-learning systems, personalization is often implemented through students modeling, adaptive navigation, or intelligent agents[8-10].

III. LIFE LONG LEARNING AND SELF-LEARNING

In recent years, there are many studies in CSCL and personalized learning, with lots of applied learning platforms or research prototypes created. With the development of knowledge economics, the concept of self-learning arise, which has been employed by many enterprises. Needless to say, self-learning is a learning by oneself or self-assisted learning, which corresponds to the model of self-teaching.

We find that the lifelong learning is often a continuing learning or a new skill training with the nature of knowledge updating, and the learners are most adults with fairly systematic knowledge and fairly strong learning capacities. So, a knowledge frame based self-learning strategy will be more suitable for lifelong learning.

A. Motivation for research on Self-learning

Our motivation to study self-learning originated from two considerations. On the one hand, the society has stepped into the times of knowledge economics, with increasing updates of knowledge, thus new skills and knowledge are in great demand so as to enhance the ability to compete in the society. Correspondently, continuing education and lifelong learning are popular among people, which are characterized by self-learning. On the other hand, CSCL and personalized learning meet the need of some people in certain aspects; however, they are mainly teacher-centered study in learning mode, not suitable for lifelong learning and student-centered self-learning model.

Self-learning and CSCL emphasize differently. In CSCL, it is the teacher who assign learning tasks and control the teaching process. CSCL emphasizes the cooperation among learners, who often have common interests and goals. With the supports of computer networks, a communicative mechanism can be set up to fulfill the learning process via conversations. But self-learning emphasizes learning by oneself, and completely centers on the learners, who make their own

learning goals. That is to say, we emphasize the communication between the learners and the system. Even without other learners on line, one learner can also fulfill his or her learning, which resembles self-teaching. Of course, we also emphasize the communication among learners.

B. Self-learning learning environment

Learning environment is the surroundings of learning, comprising learning objectives, learning materials, and technological support for corresponding learning methods. A common learning environment is illustrated as Fig. 1.

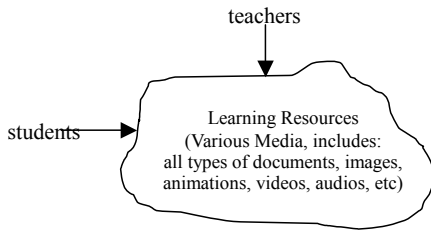


Fig.1. Leaning Environment

In traditional educational systems, textbooks are the only learning materials. But now in E-learning systems, educational resources are much more abundant than before, which include various medias, such as all kinds of documents, images, animations, audios and videos. Driven by learning objectives, learners acquire knowledge through the educational resources. As above, the design and application of learning resources are the vital factor in a self-learning environment.

IV. ORGANIZATION AND MANAGEMENT OF EDUCATIONAL RESOURCES

Educational resources are the carrier of knowledge. In an E-learning environment, the implementation of a learning strategy depends upon the organization and management of learning resources. As a advanced learning mode, self-learning is often used for knowledge updates and new skills training, we proposed a knowledge frame based method of educational resources management.

A. Layers of Body of Knowledge

The body of knowledge refers to the knowledge set which learners should master for some specific goals. It is usually organized into a series of curricula, which have an AOV learning sequence. Every curriculum has its educational objectives, and is divided into many knowledge units(KUs). Similar to curricula, all knowledge units also have a specific learning sequence. Knowledge units can further be divided into knowledge points, which are the smallest units in the body of knowledge. One or more knowledge points can be combined to make up a specific knowledge unit, and different knowledge units make up a specific curriculum.

Knowledge points are the smallest knowledge units in the body of knowledge, and we can explain them via various medium, for instance, ppts, graphs/images, animations, videos, or audios, all of which can be called learning objects(LOs). The combination of knowledge points makes up a knowledge unit, which corresponds to a web page. That is to say, there are one or more knowledge points in a knowledge unit in correspondence with different learning objects.

All knowledge points have a learning sequence, which makes up the learning process. The process is the one that we retrieve and read the learning objects data files. So, we can create a framework for a knowledge point, which is illustrated in Fig .2..

name:	
description:	
prevs:	{ }
succs:	{ }
refs:	{ }

Fig.2. KP Frame

In the figure, “name” indicates the name of a knowledge point, “description” indicates the descriptions of the knowledge, “prevs” means the preceding knowledge points set, “succ” means the succeeding knowledge points set, and “rels” means the relevant knowledge points sets.

B. LO metadata model

In E-learning, all learning resources are stored in different type of data files, which are collectively called learning objects(LOs). Learning objects are the carrier of knowledge, that is to say, the LOs are used to explain knowledge points. A metadata model of LO was proposed in SCORM[11], which is used to share learning resources. It has no knowledge

information about LO itself, so it can't provide a mechanism for dynamic utilization and re-construction of the LOs in an E-learning system..

C. The m:n Relationship between Learning Objects and Knowledge Points

In order to set up a relation between the body of knowledge and learning objects, on the foundation of SCORM standards and Dublin Core metadata, we proposed a new framework for LO, which is illustrated in Fig.3.

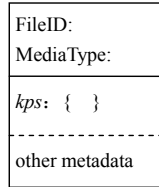


Fig.3. LO Frame

In the framework of a learning object, "FileID" means the data file identifier of the learning object; "MediaType" means the type of the learning object data file, which include text file(web page file,pdf file and ppt file etc.) , graph or image file, animation file, video file or audio file. "kps "means the knowledge points set carried in the

learning object. Other SCORM and Dublin Core metadata can also be included if necessary.

Built on the management of knowledge points, we can establish a mapping relationship between knowledge units and learning objects.

V. SELF-LEARNING BASED ON KNOWLEDGE FRAMEWORK

In the knowledge framework expression of the learning resources, because the framework has the knowledge points information of a learning object, so a mapping relationship can be established between the body of knowledge and learning objects. Therefore, with the knowledge framework, learning is the process of traveling on the knowledge network[10]. All the learning pages are built dynamically, which include a list of knowledge points with every knowledge point corresponding to a hyperlink related to a learning object data file.We call this kind of learning process as self-learning based on knowledge framework , which is illustrated in Fig 4.

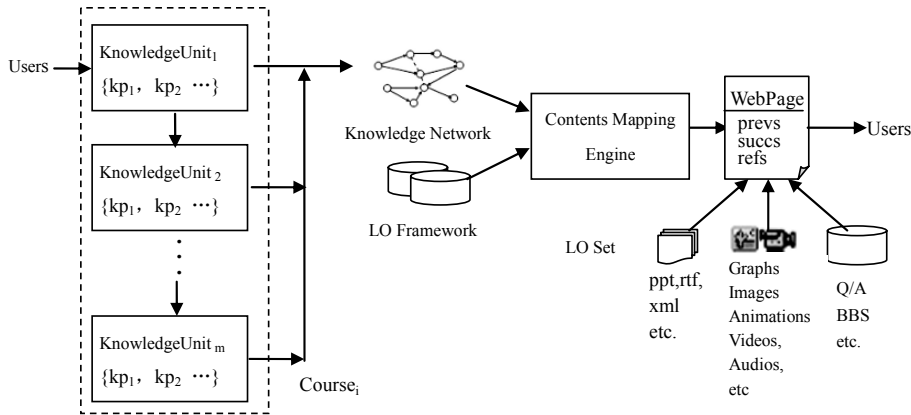


Fig.4. Learning based on knowledge framework

The mechanism of learning based on knowledge framework is more suitable for student-centered learning mode. Once the learning objectives set, the learning process will be navigated automatically by the knowledge network[10]. Meanwhile, the knowledge framework also ensure the integrity of the learning contents. The LO framework make the learning resources independent from a particular course or knowledge unit, so the learning objects can be shared and reused widely.

We had designed and implemented a generalized self-learning research prototype three years before. With the further research on it and the building of learning objects repository, the knowledge frame based learning strategy has been implemented in GSL[12]. This prototype has developed into a practical self-learning platform.

Fig. 5 shows one interface of GSL2.0.



Fig.5. Knowledge framework construction and management

The left pane is the tree structure of knowledge units. When you click one node of the knowledge tree, the corresponding description of knowledge points will be displayed in the right pane and all related LOs will also be displayed accordingly. Each LOs have a hypelink with it.

VI. CONCLUSION AND FUTURE WORK

There are many research areas related E-learning, such as: educational theories, distributed computing, computer supported collaborative work ,personalized technology and so on. Web based self-learning is a new learning mode, which absorb the strong points of CSCL and personalized learning to provide a network learning means for traditional individual learning. It will be a good learning mode for continuing education and lifelong learning in knowledge society.

Upon the above-mentioned management of knowledge points, the knowledge body can be structured. The research and application of knowledge ontology in accordance with different disciplines will be focus of our future research.

ACKNOWLEDGMENT

We would like to express our thanks to the author's graduates, Yaofeng Chang and Xu Cui, who have helped do lots of programming work in GSL.

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Design and Development of an E-learning Tool for Children to Learn How to Write the Chinese Words

Yan Liu¹, Ketao Liu², Dr. G. Scott Owen¹, Dr. Rajshekhar Sunderraman¹

¹Department of Computer Science, Georgia State University,
Atlanta, GA 30302-3994

²China-America Language and Culture Exchange Center,
Alpharetta, GA 30022

Abstract - How to make learning the Chinese language fun and interesting for young children is a non-trivial challenge to educators and/or institutions. At the China-America Language and Culture Exchange Center (CALCEC), an integrated education system (IES) is currently under development for teaching Chinese to children. This paper presents the design and development of a Chinese word-writing tool, one of the interactive e-learning tools developed at CALCEC as part of its IES. The Internet is chosen as the conveyance tool for the e-learning system. A website (www.kidchinese.com) has been built to deliver the interactive learning system to students. The preliminary survey results indicate that the interactive e-learning tool helps to keep and increase students' interests in learning the Chinese language.

I. INTRODUCTION

It is commonly believed that speaking the Chinese language can be a challenge [1] for non-native Chinese speaking young children. To write Chinese words is believed to be even more difficult [2]. Let's take one Chinese word as an example to see why it can be difficult to write. The following Fig. 1 shows a very simple Chinese word meaning "small or little".



Fig. 1. A simple Chinese Word

If you have never learned how to write a Chinese word, you may not know where to start since it is not like English, i.e., always from left to right. The correct writing sequence for this word is from the middle, then left, and then right as shown in Fig. 2.

There are many Chinese words with more than ten construction elements with more sophisticated structures. The writing sequence for each Chinese word may be different. One may be from left to right, another may be from top to bottom, and another may be from inside to the outside.

Though there are general rules [3] on the Chinese word writing sequence, writing a Chinese word in correct sequence is not always easy. Reading Chinese words is related to their writing [4]. Though, teaching young children how to read is important, teaching a student how to write Chinese words should not be neglected either.



Fig. 2. A Chinese word writing sequence

This paper presents the design and implementation of an interactive Chinese word-writing e-learning tool developed at CALCEC to help children to learn how to write Chinese word in correct stroke order. CALCEC is currently undertaking efforts to integrate the traditional classroom education, remote virtual classroom education, and interactive e-learning environment together to form a new integrated education system (IES) to help children to learn the Chinese language and culture.

II. WRITING A CHINESE WORD

Each Chinese word has a two-dimensional structure. The constructing elements for a Chinese word are called strokes. To show how to write a Chinese word, the system starts with showing how to write a stroke.

In this e-learning tool, a finite mesh is constructed for each stroke. The mesh is composed of a series of convex polygons as shown in Fig. 3.

Therefore, showing how to write the stroke on the screen is realized by filling the polygons with color in the correct sequence using a controlled speed.

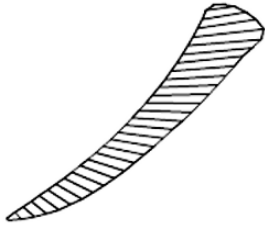


Fig. 3. A finite polygon mesh of a stroke for a Chinese word.

On the other hand, students need to practice writing the Chinese word themselves with the e-learning tool on the computer. When the tool is in the user writing mode, the mouse cursor is replaced with the image of a pen so that the user can write a word through cursor movements. Mouse cursor events are captured to judge if the user is writing within a stroke. The cursor position is within the stroke if and only if the cursor position is within a polygon of the finite mesh.

For a given convex polygon, a point is inside if and only if the summation of angles from the point to both ends of each edge of the polygon is 360 degrees as shown in Fig. 4. This is also true for a point on the edge but not on the corner.

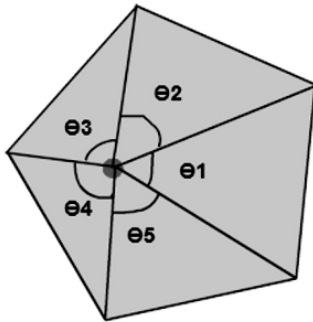


Fig. 4. A point is inside a five-edge convex polygon

If the cursor position falls inside a polygon, then the polygon is filled with the color selected by the user. As the cursor (pen) moves within the stroke, contacted polygons are filled and the user “realizes” the writing of the stroke.

The stroke sequence for a given Chinese word is predefined. Therefore, before each polygon within a given stroke is filled, the next stroke in sequence is not available for writing. In this way, the user learns the stroke sequence order when writing the Chinese word.

Since each polygon is small, a user may not notice an unfilled polygon. To prevent confusion, any unfilled polygons

are automatically filled when the polygon fill-up rate exceeds 85 percent for a given stroke.

To offer a better interface to the user, the polygon meshes are made hidden within a Chinese word framework as illustrated in Fig. 5.



Fig. 5. The framework of a Chinese word with hidden polygon meshes.

The user-computer interactive events modeled for writing a Chinese word using the e-learning tool can be demonstrated as follows in Fig. 6:

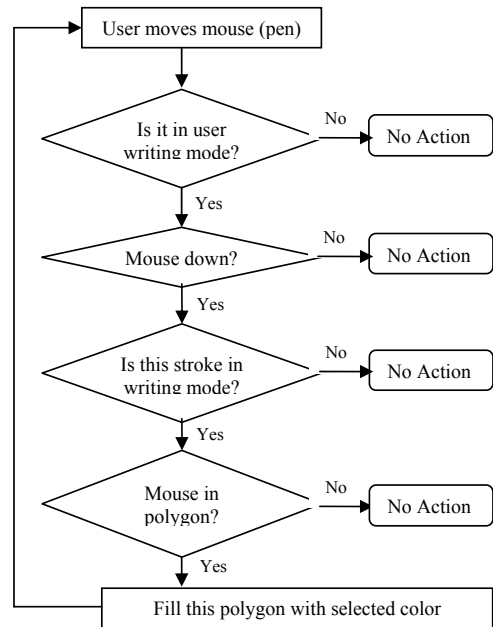


Fig. 6. A user-computer interactive events model for writing a Chinese word

III. IMPLEMENTATION

The Word Cards function in <http://www.kidchinese.com> website is implemented using the Chinese word-writing

technology described above. This technology is implemented in few main steps described in the following sections.

A. CONSTRUCT THE POLYGON MESHES

The polygon mesh for a stroke of a Chinese word is implemented as a 2x2 matrix array as follows:

$$\text{Mesh_Stroke_k} = ((x_{11}, y_{11}), (x_{21}, y_{21}), \dots, (x_{1i}, y_{1i}), (x_{2i}, y_{2i}), \dots, (x_{1n}, y_{1n}), (x_{2n}, y_{2n}))$$

Where (x_{1i}, y_{1i}) represents a point along one side of a stroke, and (x_{2i}, y_{2i}) represents a point along the other side of a stroke as illustrated in Fig. 7.

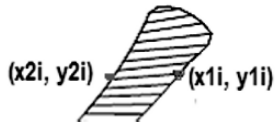


Fig. 7. Polygon mesh points for a stroke of a Chinese word

Special treatments are done for the first polygon point and last polygon point in order to have a complete cover of the stroke.

$$\begin{aligned} x_{11} &= x_{21}, y_{11} = y_{21} \\ \text{and } x_{1n} &= x_{2n}, y_{1n} = y_{2n} \end{aligned}$$

A one-dimensional array is also used to implement polygon fill indicators so that each polygon fills only once to reduce the computing time.

B. COMPUTE THE ANGLES

To judge whether or not the cursor (pen) position is inside a given convex polygon, the summation of angles of the cursor position (x_m, y_m) to each end of an edge of a polygon is calculated as follows:

$$\Phi = \sum \theta_i$$

where $i = 1 \dots 4$

$$\text{and } \theta_i = \arccos \{ (a_i^2 + b_i^2 - c_i^2) / (2.0 * a_i * b_i) \}$$

$$\text{where } a_i = \sqrt{(x_{1i} - x_m)^2 + (y_{1i} - y_m)^2},$$

$$b_i = \sqrt{(x_{2i} - x_m)^2 + (y_{2i} - y_m)^2},$$

$$c_i = \sqrt{(x_{2i} - x_{1i})^2 + (y_{2i} - y_{1i})^2}$$

C. TREAT THE CORNER POINT

If the cursor position is on a corner point of a polygon, it shall also be considered as contacting the polygon. Though

the chance is rare for a user's pen (cursor) to touch the corner point of a polygon, it is not impossible. However, a corner point does not give 360 degree angle summation to the polygon edges. It is observed that if the point is on the corner point, then the following conditions are satisfied:

$$\begin{aligned} a_i + b_i &= c, \text{ and} \\ a_i * b_i &= 0, \end{aligned}$$

where $a_i, b_i,$ and c_i are the triangle sides used in Section B.

D. TREAT SOPHYSTICATED STROKES

Though majority of the strokes used in the Chinese word go in one direction, there are sophisticated strokes that have turns. Fig. 8 illustrates one of such strokes.

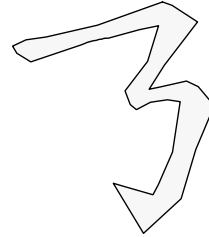


Fig. 8. A sophisticated stroke with turns

If all the side points (as shown in Fig. 7) are stored in one mesh array, it gives possibility of forming concave polygons. The resolution used in the Chinese word writing tool is to divide the stroke into segments as shown in Fig. 9.

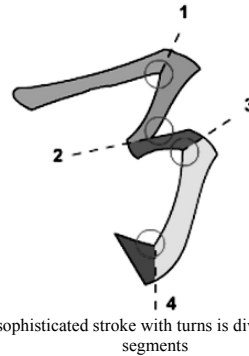


Fig. 9. A sophisticated stroke with turns is divided into multiple segments

The separation line starts from each concave corner point as indicated by circles in Fig. 9. Therefore, the sophisticated stroke is divided into 5 segments. One mesh array is used to store the side points for each segment.

E. LOCATE THE CONTACTED POLYGON

Since the polygon array for a stroke is not guaranteed in ascending or descending sorted order due to the curve shape

of edges of the stroke, a linear search algorithm is deemed to be efficient to locate the contacted polygon. The algorithm is illustrated in the following pseudo code:

```

Function Int LocateContactedPolygon () {
    K = 0;
    Kp = -1;
    While (K < PolygonArrayLength) {
        If (Not PolygonIsFilled (K)) {
            If (CursorInPolygon (K))
                Kp = K;
                Break;
            }
        }
        K++;
    }
    Return Kp;
}

```

IV. SURVEY AND RESULTS

A survey for the interactive Chinese word writing tool was given to a group of 40 students who take Kid Learning Chinese class at CALCEC. The following questions are given in the survey for each student to answer. The survey result is shown in Table I and Fig. 10.

Question Number	Question	No. of Students Answering Each Question
a	The tool is useful and increases my interest to learn Chinese	32
b	The tool is useful but does not increase my interest to learn Chinese	3
c	The tool is not really useful	1
d	The tool is not easy to use	3
e	The tool reduces my interest to learn Chinese	0
No Answer		1

TABLE I
INTERACTIVE CHINESE WORD-WRITING TOOLS SURVEY
RESULT

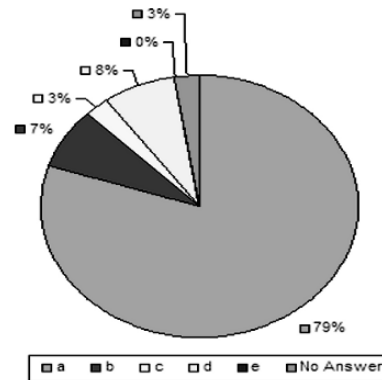


Fig. 10. Interactive Chinese word-writing tool survey result (Percentage of students answering each question)

V. CONCLUSION AND FUTURE WORK

This paper presented the design and development of an interactive Chinese word writing tool for children to learn the Chinese language. The preliminary survey results show that the interactive e-learning tool is helpful to keep and increase children's interest in learning the Chinese language. More tools will be developed and added to the website for the Integrated Education System. Further surveys will be carried out with a larger number of students. The survey results will be used to further adjust the e-learning system development and implementation.

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A Study Support System on a Hands-on Networking Laboratory

Yasuhiro Nakagawa, Hiroshi Suda, Yoshiro Miida, Masahiro Ukigai
Chiba Institute of Technology, Department of Information and Network Science,
Tsudanuma, Chiba 2750016, JAPAN

Abstract - In the present paper, we describe the mechanism and performance of a LAN building support system for the undergraduate study of LAN administration. The present system can be used to make a real hierarchic network from design information alone in a short time. Using the present system, students are able to select a LAN design for study as an administrator. The study of the administrative aspects of LAN management with active communication has become important. We built a hands-on networking laboratory in which each student is able to study LAN administration from the perspective of a user to that of a network manager, without any risks. Students are able to study how to design networks and construct servers on each domain network, which consists of a router and a number of hosts. Undergraduate students evaluated this system highly. In addition, some of the students requested additional study using a different LAN structure. By switching LAN structures, students are able to develop skills that are needed in LAN management for different design structures. Therefore, we propose a support system for more effectively and efficiently developing advanced skills in LAN administration.

Index Terms – Networking Laboratory, LAN Administration, Virtualization Technology

I. INTRODUCTION

Demands for Local Area Network (LAN) administrators are increasing along with the popularization of the Internet. LAN administrators need LAN construction and management skills regarding design, construction, maintenance and operation. LAN administrators also need to approach problem solving from various perspectives because LANs consist of a number of facilities and pieces of equipment that are affected by each other. Therefore, LAN administrators need to have a broad understanding of administration, ranging from the principals to hands-on experience, in order to solve problems such as troubleshooting.

The Internet consists of various organizational and personal networks. These networks, which are called Local Area Networks (LAN), communicate with each other using Transmission Control Protocol and Internet Protocol (TCP/IP). A minimum management unit of TCP/IP network has a unique network address that corresponds to a unique domain name. This minimum network is hereinafter referred to as the network domain or the domain network. Each LAN has one or more domain networks. The basis of domain management is largely similar for each domain networks. Therefore, administrators have to understand the domain network and its communication methods in order to acquire LAN management

skills. It is important not only to study domain network management theory, but also to have hands-on experience in a real network environment and to have practical knowledge of its connections.

On the business front, there are vendors that have hands-on education programs focusing of their own facilities or software [1]-[3]. Whereas on the educational front, there are networking laboratories in which students are able to study networking administration on hierarchic network [4]-[6]. Recently, a laboratory that has added a remote accessibility function has introduced the same kind of study [7]. These approaches focus mainly on network or system management, which is sufficient for each type of study. However, these approaches are not sufficient with respect to comprehensive recognition of the relative activity of facilities.

In order to train future LAN administrators, we developed a hands-on networking laboratory. This environment enables students to study LAN administration with administrative privileges and no risk. This learning environment consists of some hierarchic networks, such as real organizational networks. Using pluggable disks for easily swapping out hard drives, disks having various OS and server configurations are made available to the student, who can select any host for study. However, the number of facilities limits the number of students who can use the environment at the same time. We resolved this problem using computer virtualization technology. Computer virtualization technology is able to execute a number of emulated hosts on a physical computer, within the limits of the computer resources. Using this technology, we constructed a learning LAN environment in which multiple students can study simultaneously. In this environment, each student, as a domain administrator, is able to study LAN administration from the perspective of a user to that of a network manager, without any risks. Undergraduate students evaluated this system highly. In addition, a number of students requested more study using different LAN structures. However, LAN construction requires sufficient time because manual procedures are needed for each step. Therefore, it is not easy to comply with student demanded LAN design in hands-on networking laboratories.

In the present paper, we propose a support system for LAN construction in order to meet the requirement for a personalized environment for each theme. In the next section, we describe the networking laboratory targeted by the support system.

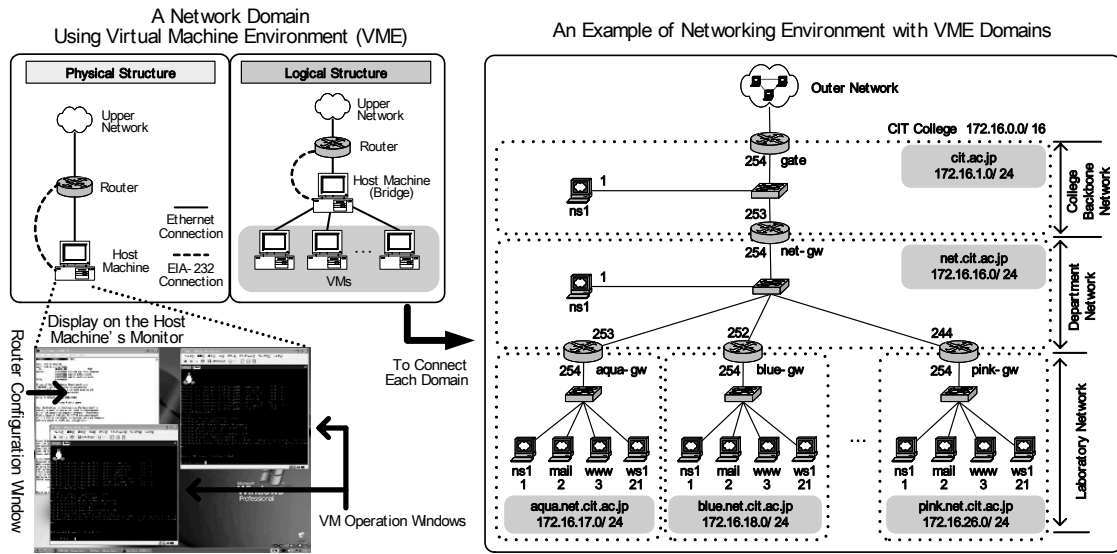


Fig. 1. A hands-on networking laboratory using computer virtualization technology

II. HANDS-ON NETWORKING LABORATORY

For the purpose of hands-on learning with respect to LAN administration, we built a networking laboratory. In this environment, each student is able to study LAN administration from the viewpoint of a user to that of a manager with administrative privileges. The goal of the present study is for students to comprehensively obtain skills ranging from LAN design to management. For this purpose, we built an independent domain network for each student using computer virtualization technology.

Fig. 1 shows the structure of the laboratory. This domain network mainly consists of two devices, a router and a personal computer (PC). Generally, each domain has one or more hosts, consisting of a DNS server, a mail server, a web server and a network client. We use computer virtualization software for the PCs to make host-members flexibly. This enables a physical computer to execute some emulated computers. The physical computer is called a host-machine (HM). The emulated computer is called a virtual-machine (VM), and its screen is displayed on the screen of the HM as a window application, which is executable simultaneously. In this technology, a disk drive image of the VM is saved as a file in the disk drive of the HM. Using this characteristic, we are able to duplicate or initialize a VM only to copy a set of image disk files. Using the above environment, students are able not only to study domain network administration, but also to study hierarchic LAN management by connecting with each domain network. We used VMware workstation (VMware Inc.) as virtualization software because of its virtualization performance. We constructed 20 sets of domain networks for 20 students and made course contents for LAN administration.

Fig. 2 shows an overview of this networking laboratory. The course is designed as a two-phase study. The first phase involves domain network building with a domain administrator role, and the second phase involves LAN building to connect each domain network. Students are able to study domain and LAN administration at the same time through this curriculum using this environment.

III. SUPPORTING SYSTEM FOR LAN CONSTRUCTING

Building a LAN involves a number of steps, such as requirement definition, LAN information design, cabling, software installation, configuration of devices and software, verification of each device activity and network communication. All of these steps require sufficient time

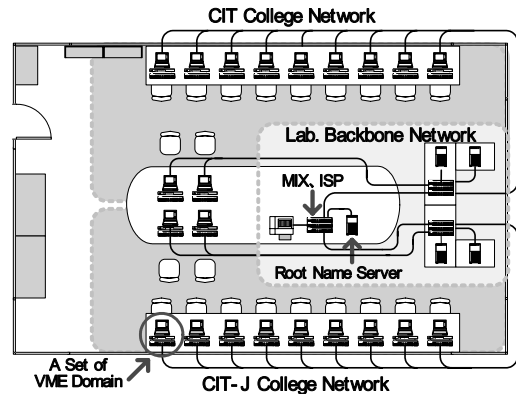


Fig. 2. An overview of the networking laboratory

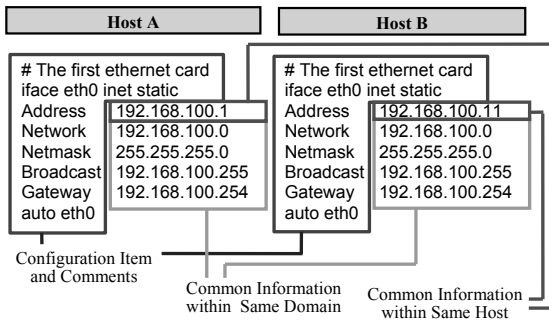


Fig.3. Configuration comparison between two hosts on the same domain

because manual procedures are needed. Therefore, it is not easy to comply with student-requested LAN designs in our hands-on networking laboratory. In this situation, if requirement definition and the designing information process have already terminated, we have only to perform the LAN building process: cabling, installing, configuring and verifying. The verification process is mainly required because of the manual configuring process. The cabling time is less than the other LAN building processes at the laboratory because the LAN devices are all located in the same room. Therefore, if installation and configuration are processed automatically from only design information, then the LAN building time can be reduced.

In this section, we describe a mechanism for simplifying configuration design and a LAN build support system to reduce build time.

A. Simplification of Configuration Making

Several configuration files are required for configuration. However, the amount of design information is less than the amount of information that we actually have to enter into the configuration files. This tendency is found in all configuration files of LAN equipment. Configuration files of networking service have commonality of description because the files are created based on common LAN design information. Fig. 3 shows an example of configuration comparison between two hosts on the same domain. The configuration content is for a network interface on the Debian Linux operating system (OS). There are three types of information in these configurations: domain, host, and unique description of the configuration file. Therefore, to simplify configuration file generation, we divided all configuration files into the following three file types: domain information files, routing information files, and template files.

The domain information file deals with hierarchic information between the domain network and its hosts. The routing information file deals with information about routing among domain networks and router interfaces. The template file consists of the remaining descriptions that replace the above information with identifying tags. To easily describe the hierarchic relationship and to simply write configuration files in plain-text format, the domain and routing information files are written in eXtensible Markup Language (XML) and the template file is written in XML Stylesheet Language (XSL). Fig. 4 shows an example of how to make configuration files from these information and template files. The above-described flow is shown on the left, and contents of the created files are shown on the right. To overwrite the files to initialized devices, the host and router building processes are completed. The build target hosts are VMs in our laboratory.

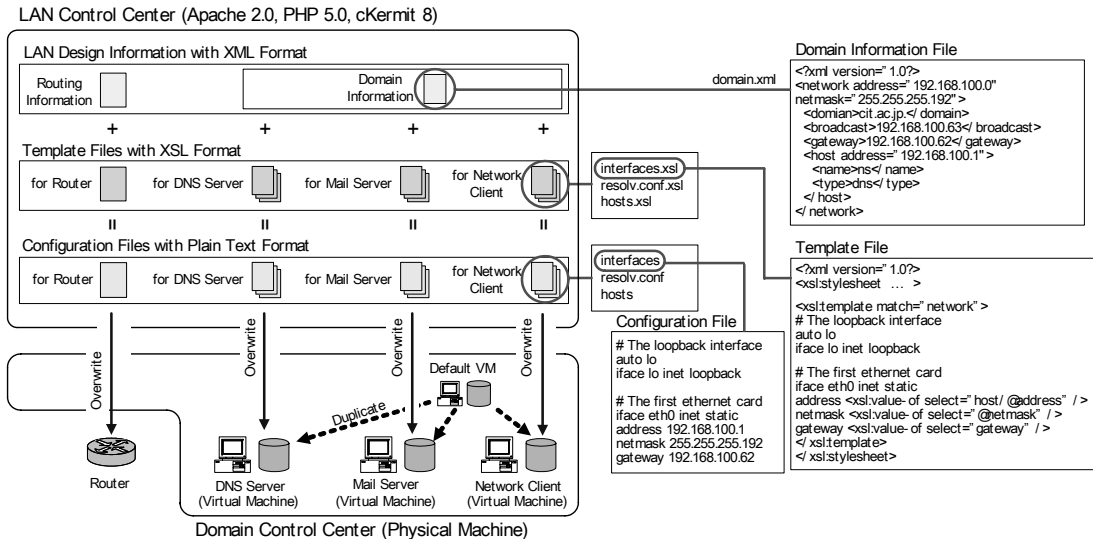


Fig.4. Making configuration from design information and template files

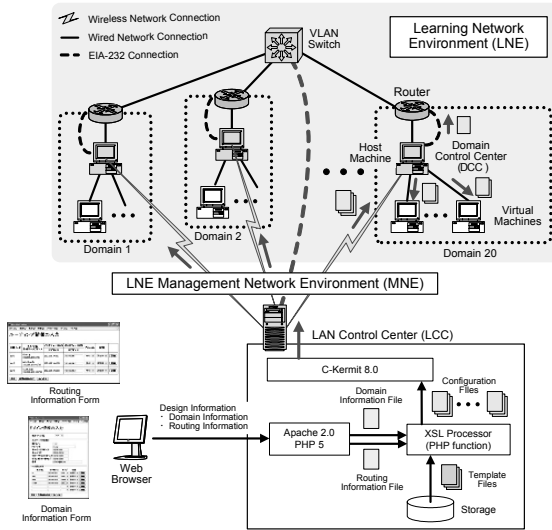


Fig.5. An overview of the LAN constructing system

Therefore, we are able to shorten the installation time required to prepare the default image file for host building and to copy this image file as necessary. To easily set up target VM disks from common one, OS and needed application programs, which are BIND, Postfix, Apache and so forth, are already installed on the default image. Using these two mechanisms, we realized a considerably shortened LAN build time.

B. LAN Building System

To further reduce the build time, we constructed an automatic LAN building system in order to use the simplification mechanism of configuration design. A target LAN is able to be built on the system from its design information. We constructed, in detail, a server called the LAN control center (LCC) to control the LAN building process and a learning network environment (LNE) to transfer configuration files to the target devices.

Fig. 5 shows the structure of this build system and its transfer operation. The system consists of two network environments, the LNE and its management network environment (MNE). The LNE is a hands-on network environment (described in chapter 1) and consists of 20 domain networks with computer virtualization technology.

The MNE consists of a LCC and a number of DCCs. These control centers are able to directly communicate with each other through a wireless LAN. The LCC has three main roles: to make configuration files, to control the LAN construction process, and to transfer files to DCCs. The DCCs have two roles: to duplicate VMs at the request of the LCC, and to relay the files to a router and to the VMs. Because HMs have direct ties with a router and the VMs at the same domain, they assume the role of this DCC to bridge network function. The default image disk for the VM is already configured with

respect to the network interface. The LAN building procedure is as follows:

1. Entering the LAN design information via a web browser by an instructor or student
2. Saving the information in XML on the LCC
3. Making configuration files for LAN devices on the LCC
4. Powering on the VMs and routers
5. Transferring the files from the LCC to the HCC
6. Duplicating a default disk image on the HCC
7. Transferring the files from the HCC to a router
8. Shutdown of all VMs, and powering off of all VMs and routers

After performing all of the above procedures, students are able to study on the network environment specified by the design information. The support system basically automates only inner domain building without cabling. Therefore, the connection among domains has to be wired by hand. However, for the case in which the LAN's member domains are connected to the same network, no cabling is needed because the system is automatically split between LANs to make the VLAN configuration.

To realize this mechanism, the LCC uses Apache 2.0 and PHP 5.0 with an XSL processor for entering the information to generate the configuration files, and uses C-Kermit 8.0 for direct control of the DCC and indirect control of the router and VMs through the HCC. To receive an LCC remote control, the DCC uses Cygwin, a Linux-like environment on Microsoft Windows, and a UUCP program, which is able to relay an LCC TCP connection to a router as an EIA-232 connection to be executed on the xinetd program. There are two information forms by which to enter design information: the domain information form and the routing information form. The host type and build-status are selectable. The host type item is readied with respect to a DNS server, a mail server, a web server and a workstation. The status item is readied with respect to "nothing", "OS installed only" and "All Configured", referring to the disk drive image condition of the VM. The "nothing" status indicates that no software is installed, including an OS. The "OS installed only" status indicates that the OS has been installed. The "All Configured" status indicates that all necessary configurations have already been set up. The student is able to study the target host by selecting "nothing" or "OS installed only" as the status.

IV. SYSTEM EVALUATION

To confirm the system performance, we measured the build time using the LAN build support system explained in previous section. In this section, we describe the result of two LAN build experiments. The build targets are a DNS server and mail server build study by two students. This experiment is based on a student request that was received after studying LAN administration with the proposed networking laboratory, as explained in Chapter II.

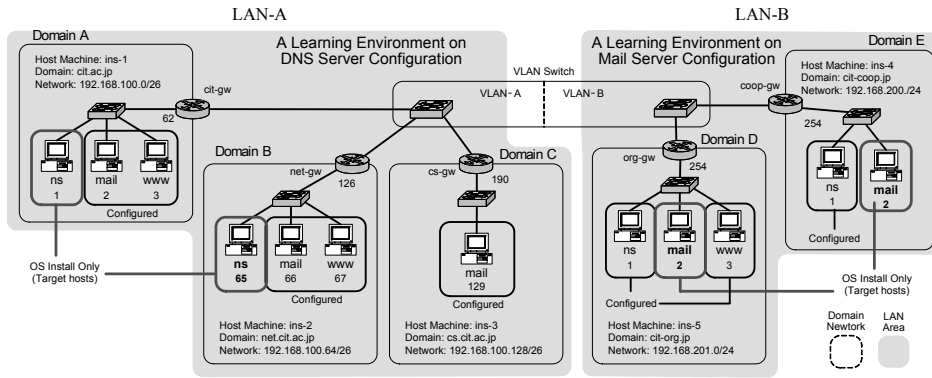


Fig. 6. An example of constructing LANs with two learning tasks

A Flow of LAN Building

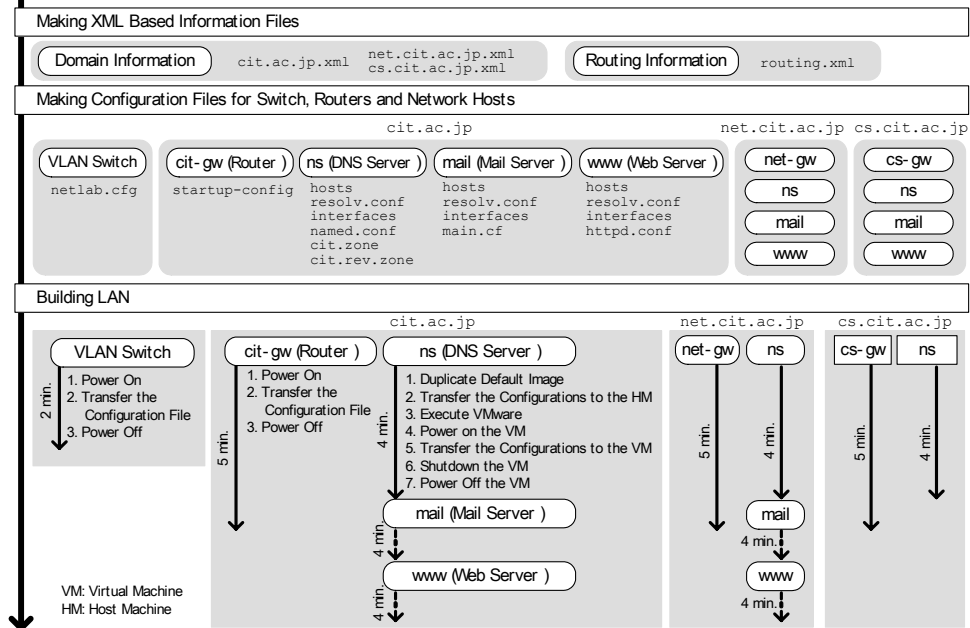


Fig. 7. A constructing flow on an experiment about LAN-A build

Fig. 6 shows the network structure of target LANs, called LAN-A and LAN-B. The physical equipment used in this experiment includes a LCC, a VLAN switch and five domain networks, each of which consists of a router and PC. The target of LAN-A is DNS server communication, and the LAN consists of three domains: A, B and C. In order that students are able to study efficiently, for the DNS servers in two domains, A and B, the operating systems are installed but are not configured. The remaining name server in domain C is prepared for a communication test between DNS servers. The target of LAN-B is mail server communication, and in the mail servers in two domains, the operating systems are

installed but not configured. Domains A, B and D have three hosts: a DNS, a mail server, and a web server. Domain E has two hosts: a DNS and a mail server. Domain C has only one host: a DNS. The member features of this test are as follows:

- LNE Control Center (CPU: Celeron 800 MHz, Memory: 512 M bytes)
- Domain Control Center (CPU: Pentium III 1 GHz, Memory: 1G byte)
- Virtual Machine (OS: Debian Linux 3.1, Memory: 64 Mbytes, Disk: 1G byte (500M bytes used))

We evaluated the build time for three experiments: LAN-A build, LAN-B build, and LAN-A and LAN-B build. Fig. 7 shows the construction flow for the LAN-A build. There are three processes in all of the builds: making design information files, making configuration files and constructing the LAN. After the design information is entered through a web browser, three domain information files and a router information file were created. By clicking the 'make' button on the web browser, all configuration files are automatically made and saved in the LCC approximately simultaneously. Therefore, the times of the first two processes depend on the time required to enter information via the web browser. The last process shows the procedure and the required time for each domain building. All of the domains were built simultaneously because the DCC, which controls domain construction, existed in each domain. The building of a router and VMs was also executed simultaneously. However, the VM building process was executed sequentially because of the disk load of the HM with regard to duplicating disk image processes.

Table I shows the relationship between the domain number and the host number. From the simultaneity explained above, the domain build and LAN build times are determined to basically depend on the VMs build time. The reason for flat appearance of the build time is that each process in building is controlled by the LCC and is adjusted to be flat because there are estimated time factors in some processes, such as OS booting. For reference, the build time relating the total number of domain network members is shown in Fig. 8.

TABLE I
RELATIONSHIP BETWEEN DOMAIN NUMBER AND HOST NUMBER

Target	Amount of Domain	Domain Construction Time					LAN Construction Time
		A	B	C	D	E	
LAN-A Only	3 (A, B, C)	12	12	5	/	/	12
LAB-B Only	2 (D, E)	/	/	/	12	8	12
LAN-A + LAB-B	5 (A, B, C, D, E)	12	12	5	12	8	12

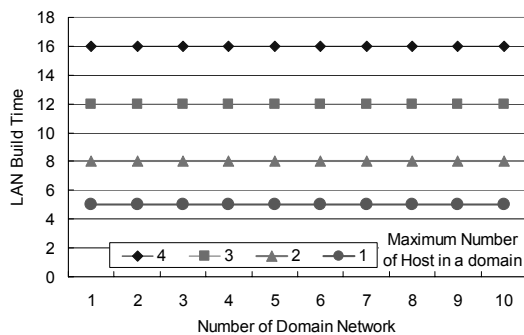


Fig.8. Build time relating total number of domain network member

V. PILOT STUDY EVALUATION

Pilot study experiment using the supporting system, were conducted in a networking course with ten undergraduate students. Before they use a network built by this system, the students studied LAN working in classroom lectures and learned how to design and construct a domain network on our networking laboratory that we described in the second section. On the study of LANs building that are designed by their own, we construct a part of LAN that students are designed for the request of three students of ten. We could get better response from the students about their confidence better than the others.

VI. CONCLUSION

We constructed a support system for LAN construction in response to requests by students for a personalized environment for each LAN construction theme. From the result of the LAN build experiment, the proposed system is effective for LAN build support and meets the needs of students with regard to having personalized environments.

Further study regarding the variation of LAN design and student evaluations after the introduction of the networking course will be performed in the future.

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User Modeling in the Context of Cognitive Service Delivery: Application to Learning Management Systems

Y. Kritikou, P. Demestichas, *University of Piraeus – Department of Digital Systems, Greece*
kritikou@unipi.gr

E. Adamopoulou, K. Demestichas, *National and Technical University of Athens - Department of Electrical and Computer Engineering, Greece*

Abstract—A contemporary trend in the field of telecommunications is the development of a constantly increasing number of services available to users through computer networks. These services are being used in order to facilitate users' everyday life and save them time and effort. The following paper discusses on the service delivery and the way it can be adapted to each user's specific needs, in the context of cognitive networks and service provisioning. An example of such a service is being examined, namely a Learning Management System and specifically User Model entity, which is responsible for storing user's preferences. In support of this vision, a paradigm of Bayesian Networks' application is presented, aiming at predicting user's preferences in a Learning Management System, by managing a specific set of parameters that affect it and providing the information to configure the learning content to be delivered, accordingly. For the confirmation of this Model's validity a set of indicative results are also presented at the end of this paper.

Index Terms—E-learning, Learning Management System, Service Provisioning, User model

I. INTRODUCTION

THE last years have witnessed an explosion of activity around science and particularly in telecommunications. Today, someone is able to make a phone call, download his e-mails, make a videoconference or simply take some notes by using a single device. This means that users' have, and are encouraged to, become more demanding, requiring more complex services. On the other hand, service delivery cannot

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Yiouli Kritikou and Panagiotis Demestichas are with the University of Piraeus, Department of Technology Education and Digital Systems, Karaoli and Dimitriou 80 Str, Piraeus 18534 (Telephone number: +30 210 414 2749, +30 6944 518 685, e-mail address: kritikou@unipi.gr)

Evgenia Adamopoulou and Konstantinos Demestichas are with the National Technical University of Athens, Department of Electrical and Computer Engineering, Iroon Polytechnείου 9 Str. Zografou, Athens, 15780

be the same for every user, since their expectations and preferences on the service features are most likely to differ between them. This means that it is necessary to reinforce the service delivery with a certain cognitive mechanism, able to collect, manage and effectively provide information to users. Thus, networks need not only to be able to provide users with advanced services, but also manage the information users' provide them, in order to evolve the service, so as to meet their needs.

In this context, this paper presents cognitive networks and service provisioning, developed to process users' needs and adapt the service to be delivered to them accordingly. More specifically, in Section II a brief description of network operation takes place, while in Section III cognitive networks and service provisioning are discussed. In Section IV management functionality is presented in order to support service delivery in a Learning Management System and more particularly, management functionality focused on User Model, for predicting users' needs. Finally, in support of this vision, we elaborate on the Bayesian Network Model (Section V), applied to predict users' preferences by observing the values of a certain set of parameters, as well as some indicative results concerning the application of this model. Summary, conclusions and future work are closing this paper in Section VI.

II. NETWORK OPERATION

As previously mentioned, today there are plenty of services offered with the aim to satisfy users' particular needs, along with a lot of different ways to achieve this service usage. For example, through a device a user may be informed of the flights' schedule to New York, the weather of the next days or the way to reach the house of a friend of his, in case he is lost. He only has to use a program to find a particular service and then require more specific information by sending it to his Service Provider. For this communication to be achieved the existence of a Network Infrastructure is essential, responsible for facilitating the communication between the user and the server, providing him the services he requests, as graphically

depicted in Fig. 1.

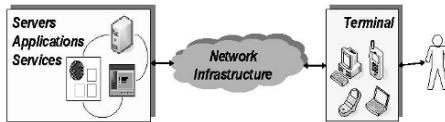


Fig. 1. Communication established between user and server

The communication between the terminal and the server would be impossible without the Network Infrastructure, for obvious reasons. The Network Infrastructure receives information from both the user and the server and ensures that this information will be distributed accordingly. Users usually request for a specific service or application. In this way, a simple form of communication between user and server takes place, in order to satisfy the users' requests. Of course, the things are not so easy and simple in the actual service or applications' requests, since current requirements for services are complicated and demanding.

The next section discusses on networks' infrastructure enhancement with cognitive features, in order to be able to manage effectively the knowledge it acquires on user's preferences and the context he is in and finally deliver to him the appropriate service.

III. COGNITIVE NETWORK INFRASTRUCTURES AND SERVICE DELIVERY

Current network infrastructures seem to become more and more complex, as the demand for more complex services increases. This means that networks are being developed with regard to supporting the delivery of services to users', e.g. e-services [10]. Yet, it is extremely difficult and time consuming for a user to learn how to use each e-service. Time and effort increase dramatically in case the user is not accustomed to using such services and equipment. In order to make networks appear simpler and thus more accessible and available for a bigger proportion of users, Cognitive Networks and Service Provision are proposed as a solution for this problem. Cognitive networks [9] aim at achieving external simplicity, while disguising the complexity of networks, optimizing overall network performance. Context – awareness is the ability to know the place the user is, what equipment he is using and the service he wants to access. Service provisioning has set its goals in predicting user's demand for e-services. This is achieved by acquiring telecommunications service from the submission of the requirement through the activation of service [10].

This creates the necessity for the development of Advanced Management Functionality, both on network's side and on application's side. In other words, it is essential to create cognitive mechanisms for managing network's decisions as far as its actions for the type of service to be delivered and the features incorporated in this service (technical features of the service) are concerned, as well as cognitive mechanisms for managing the decisions an application makes regarding the

content to be delivered.

In support of this vision, the following section discusses on a part of Management Function applied to a Learning Management System and more specifically to the User Model.

IV. LEARNING MANAGEMENT SYSTEM AND MANAGEMENT FUNCTIONALITY FOR COGNITIVE SERVICE DELIVERY

As mentioned in the previous section, e-services are developing at very high rates and are available through computer networks, which have become notably complex. Such e-services aim at replacing user's presence in a conventional environment, providing him the opportunity to complete certain tasks through a device, by simply accessing an application or platform. One such e-service is e-learning, which refers to computer-enhanced training [8].

As depicted in Fig. 2, an e-learning platform, or Learning Management System, comprises four main entities, each of which playing a separate, irreplaceable role for the platform's operation. More precisely, Domain Model stores the sections of each learning field and accordingly composes the learning material, as requested from the User Model and the application Server. The User Model keeps separate records for each user, regarding his interests, his preferences, his skills, the level of knowledge on the subject and his goals, according to the course he is about to "attend". Moreover, log files about the user's history, the learning path he follows each time he visits the platform and his general behavior during his navigation in the system, as well as data concerning the context, and more specifically the equipment/ device and the technology (wired or wireless connection) he usually uses to access the platform, are also elements stored in the User Model. Finally, the Learning Management System provides the user with a set of exercises and tests at the end of each lesson, along with evaluation and self evaluation tests at the end of each course, in order to verify and assess the acquired knowledge, which are managed by Exercises – Tests and Evaluation – Self Evaluation entities, respectively.

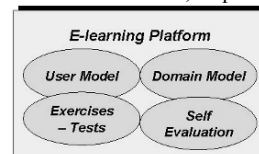


Fig. 2. Components of the e-learning platform

The User Model entity, being the one to store the user's general behavior and preferences information, affects to a great extent the information the system decides to provide him each time he inquires something. This means that, if well evaluated, the parameters kept in the User Model are able to configure the content to be delivered to him, adapted to each user's needs and expected outcomes. Another factor that should be taken into account is that the parameters mentioned previously change as the user enhances his knowledge, because of taking the offered courses of the platform.

Thus, considering these elements, we presume that in order to achieve correct content configuration and delivery, it is

essential for the User Model to be enhanced with a certain point of cognition. This means that the User Model will have to be equipped with a mechanism able to collect information, plan, decide and finally act upon the collected information. Management Functionality has this role, aiming at aiding the Learning Management System make the correct decision on the content to be delivered to the user. This means that Management Functionality collects information on user's context and effectively decides on the content to be delivered to users.

Bayesian Networks provide a mechanism, which can support the probabilistic inference of user's preferences, by observing a certain set of parameters and thus provide the way to manage the information to be presented. This mechanism is thoroughly presented in the next section.

V. USER MODELING THROUGH LEARNING BAYESIAN NETWORKS

This section discusses on the prediction of user's preferences, using Bayesian Networks.

A. Bayesian Inference

In this section, we propose an approach to the problem of user preferences prediction based on a system that models user preferences and the causal relationships between them using Bayesian networks. Bayesian networks are directed acyclic graphs with network structures that encode conditional independence assertions about a set of variables [1]-[3].

Bayesian networks have proven to be valuable tools for encoding, learning and reasoning about probabilistic relationships, and once they have "learned" the correct structure and parameters, they may support probabilistic inference of the user's preferences [4]-[7].

B. User Preferences Modeling

Without loss of generality, let us assume that a user's profile is characterized by two parameters: (a) the content's preferred *level* of difficulty, and (b) the suitable type of *interface*. These are the model's target parameters, i.e. the parameters whose most probable values we are trying to approximate, in order to deduce the most probable user profile. Possible discrete values for these two parameters are, respectively: (a) "Low", "Medium", "High", and (b) "Type 1" (i.e., simple and plain), "Type 2" (i.e., simple but attractive), "Type 3" (i.e., complex but plain), "Type 4" (i.e., both complex and attractive).

In order to offer personalized learning experience, we consider that each user has his unique profile, his own needs and capabilities. Thus, our final goal is the determination of the most probable values of the parameters *level* and *interface* for a specific user. Fig. 3 is a representation of the corresponding probabilistic model.

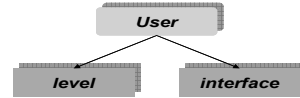


Fig. 3. Probabilistic model for the prediction of user preferences

In order to estimate the most probable values of these two variables, the determination of a set of estimation (predictive) parameters affecting these values is needed. For our case, we can consider two predictive parameters: (a) *time* needed to complete a lesson, and (b) the corresponding performance (i.e., *grade*). Possible discrete values for these two parameters are, respectively: (a) "Slow", "Medium", "Fast", and (b) "A", "B", "C".

The predictive parameters affect the target ones, in the way depicted in the model of Fig. 4.

As it is obvious, the value of the target parameter *interface* is determined only by the *time* needed to complete a learning unit, whereas the *level* is affected by both the *time* and the *grade* of the trainee.

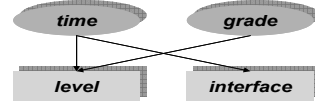


Fig. 4. Probabilistic model for learning and adaptation

For the remainder of this subsection we will use the notations depicted in Table I.

Table I. Parameters' Notation

Name	Symbol
Level	ℓ
Interface	i
Grade	G
Time	T
User	U

The goal is the computation of the maximum value of the joint conditional probability $P(\ell, i | U = U_j)$. In what follows we prove that the desired probability $P(\ell, i | U = U_j)$ is equivalent to the computation of the products of the conditional probabilities $P(\ell | U = U_j)$ and $P(i | U = U_j)$, i.e.:

$$P(\ell, i | U = U_j) = P(\ell | U = U_j) \cdot P(i | U = U_j) \quad (1)$$

Relation (1) means that the two predictive parameters, level and interface, can be decoupled. Two independent conditional probability tables (CPTs) can, consequently, be organized.

Table II shows a sample of the structure of a CPT for level.

Table II. Sample of the CPT for parameter *level*

Interface	$U = U_1$	..	$U = U_n$
$i_1 = \text{"Type 1"}$	$P(i=i_1|U=U_1)$	..	$P(i=i_1|U=U_n)$
$i_2 = \text{"Type 2"}$	$P(i=i_2|U=U_1)$	..	$P(i=i_2|U=U_n)$
$i_3 = \text{"Type 3"}$	$P(i=i_3|U=U_1)$	..	$P(i=i_3|U=U_n)$
$i_4 = \text{"Type 4"}$	$P(i=i_4|U=U_1)$	..	$P(i=i_4|U=U_n)$

The CPT for interface is similar.

The proof of relation (1) starts from the Bayesian chain rule

formula, which suggests that:

$$P(\ell, i, U=U_j) = P(U=U_j) \cdot P(\ell | U=U_j) \cdot P(i | \ell, U=U_j) \quad (2)$$

Assuming that the value of interface is independent of the value of level, it can be deduced that:

$$P(\ell, i, U=U_j) = P(U=U_j) \cdot P(\ell | U=U_j) \cdot P(i | U=U_j) \quad (3)$$

According to the joint probability formula:

$$P(\ell, i, U=U_j) = P(U=U_j) \cdot P(i, \ell | U=U_j) \quad (4)$$

Hence, from (3) and (4), relation (1) is proved, thus the calculation of the desired conditional probability can be achieved by computing the product of two simple conditional probabilities.

C. Learning and Adaptation

In the previous subsection, focus was given on the problem of user preferences modeling. In order to construct a complete approach, we need to investigate how to achieve the learning and adaptation of the proposed model. This is the part where the estimation (predictive) parameters are involved. By monitoring their values, we can utilize them, in order to properly adjust and correct the probabilities of the target parameters. In this way, the system receives feedback about the user's profile through tracking the values of the predictive parameters, and thus gains knowledge which can, thereafter, be exploited for the provision of automatic personalized learning experience.

Based on the model of Fig. 4, it holds that:

$$P(\ell, i, T = T_m, G = G_n) = P(T = T_m, G = G_n) \cdot P(\ell | T = T_m, G = G_n) \cdot P(i | \ell, T = T_m, G = G_n) \quad (5)$$

By considering that the probable values of level are independent from the probable values of interface, (5) becomes:

$$P(\ell, i, T = T_m, G = G_n) = P(T = T_m, G = G_n) \cdot P(\ell | T = T_m, G = G_n) \cdot P(i | T = T_m, G = G_n) \quad (6)$$

In addition, it holds that:

$$P(\ell, i, T = T_m, G = G_n) = P(T = T_m, G = G_n) \cdot P(\ell, i | T = T_m, G = G_n) \quad (7)$$

Thereby, from (6) and (7), and by applying the independency of the values of interface from the values of grade:

$$P(\ell, i | T = T_m, G = G_n) = P(\ell | T = T_m, G = G_n) \cdot P(i | T = T_m) \quad (8)$$

The computation of the conditional probabilities $P(\ell | T = T_m, G = G_n)$ and $P(i | T = T_m)$ will be conducted through the use of suitable conditional probability tables (CPTs), the values of which are predefined, and based on statistical data and the opinions of learning experts.

From the computation of the maximum conditional joint probability $P(\ell, i | T = T_m, G = G_n)$ (relation (8)), the most probable values of level and interface are inferred. Let us denote as (ℓ_u, i_v) the most probable values of the couple

(level, interface). Consequently, the corresponding probabilities $P(\ell = \ell_u | U = U_j)$ and $P(i = i_v | U = U_j)$ should be reinforced appropriately, in order to accomplish the system's adaptation.

D. Results

In this scenario, we will examine the model's behavior in a random situation, using a more realistic example. We take as a fact that w_{hist} and $w_{instant}$ reflect the weights attributed to the historical estimation and the current instantaneous estimation, respectively. In this scenario the value of the ratio $w_{hist}/w_{instant}$ has been set equal to 1.

The causal relationships between the parameters under consideration in this scenario are as follows (Fig. 5):

- Content Difficulty dependencies: This parameter depends directly on the values of all evaluation parameters. The actual lesson duration, the test duration and the user's performance dictate the difficulty level of the content that should be provided in the next lesson to the user.
- Content Volume dependencies: The volume of the content that should be provided in the next lesson to the user is affected by the time needed to complete both the previous lesson and the corresponding test. The Content Volume's dependency on the performance can be considered negligible, since large content volume does not necessarily suggest great difficulty.
- Interactivity dependencies: It is assumed that the degree of the required interactivity is determined solely by the user's past performance. More specifically, if a user achieves low performance, it is quite probable that he needs further guidance, thus more interactivity, through the lesson.
- Lesson Interface dependencies: It is realistic to assume that the only indicator affecting the type of interface needed throughout a lesson is the amount of time that the user has spent in the previous lesson.

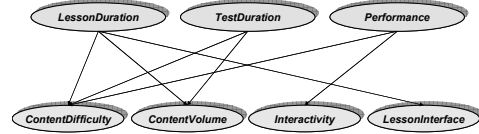


Fig. 5: Bayesian network employed by the Modeling and Evaluation Layer

The notations depicted in Table III will be used for estimating the desired probabilities.

Table III: Parameter Notations

Parameter	Notation
LessonDuration	LD
TestDuration	TD
Performance	R
ContentDifficulty	CD
ContentVolume	CV
Interactivity	I
LessonInterface	LI

Initially (step 0), as depicted in Fig. 6(b), all the possible

values of each target parameter are considered equally probable (uniform distribution). Hence, a lesson with random content difficulty, content volume, interactivity and interface is generated and delivered at this step. At the end of this lesson, the model’s monitoring mechanism reports the following evidence: Lesson Duration = Medium, Test Duration = High, Performance = C. This set of evidence serves as input for the formation of the next lesson, i.e. the lesson of step 1, as depicted in Fig. 6(a). At the beginning of step 1, the aforementioned evidence is utilized in order to produce a set of instantaneous probability estimations concerning the target parameters. This is carried out with the use of equation:

$$P(CD, CV, I, LI | LD, TD, R) = \frac{P(CD | LD, TD, R) \cdot P(CV | LD, TD) \cdot P(I | R) \cdot P(LI | LD)}{P(CD | LD, TD, R) \cdot P(CV | LD, TD) \cdot P(I | R) \cdot P(LI | LD)}$$

making use of the Bayesian Model, as thoroughly described in Section V, after setting LD=Medium, TD=High and R=C. Subsequently, the instantaneous estimations of this step (step 1), in conjunction with the adapted probability estimations of the previous step (step 0), are utilized for the computation of

the adapted probability estimations (Fig. 6(c)) of the current step (step 1). Based on the adapted probability estimations, we come to the conclusion that, at step 1, Low is the most probable value for Content Difficulty, Medium for Content Volume, High for Interactivity, and Rich for Lesson Interface. Thus, the lesson of step 1 should comply with these suggestions, in order to best fit the user’s preferences. The same method is followed for inferring the most probable values of the target parameters throughout the rest of the steps.

Based on the results of Fig. 6(c), we construct the diagrams of Fig. 7. As may be observed from the curves of Fig. 7, the adapted estimations smooth out the sharp fluctuations of the instantaneous estimations, which is the desired behavior. Indeed, they tend to moderate the fast oscillations of the instantaneous estimations, by adapting to the evidence at a slower pace. This has the clear advantage of exploiting not only the most recent evidential data, but also knowledge about the past.

Step	Evidence		
	LessonDuration	TestDuration	Performance
0	-	-	-
1	Medium	High	C
2	Medium	Medium	B
3	Low	Low	A
4	Low	Low	A
5	VeryHigh	VeryHigh	D
(a) 6	Medium	Low	A

Step	Instantaneous Estimations												
	ContentDifficulty			ContentVolume			Interactivity			LessonInterface			
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Simple	Normal	Rich	Advanced
0	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.25	0.25	0.25	0.25
1	0.5	0.3	0.2	0.35	0.5	0.15	0.2	0.3	0.5	0.1	0.3	0.35	0.25
2	0.3	0.3	0.4	0.15	0.45	0.4	0.5	0.3	0.2	0.1	0.3	0.35	0.25
3	0.1	0.2	0.7	0.1	0.2	0.7	0.6	0.3	0.1	0.1	0.25	0.3	0.35
4	0.1	0.2	0.7	0.1	0.2	0.7	0.6	0.3	0.1	0.1	0.25	0.3	0.35
5	0.7	0.25	0.05	0.75	0.2	0.05	0.1	0.2	0.7	0.45	0.35	0.15	0.05
(b) 6	0.2	0.2	0.6	0.15	0.25	0.6	0.6	0.3	0.1	0.1	0.3	0.35	0.25

Step	Adapted Estimations												
	ContentDifficulty			ContentVolume			Interactivity			LessonInterface			
	Low	Medium	High	Low	Medium	High	Low	Medium	High	Simple	Normal	Rich	Advanced
0	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.25	0.25	0.25	0.25
1	0.40	0.33	0.27	0.36	0.40	0.24	0.27	0.33	0.40	0.17	0.28	0.29	0.26
2	0.35	0.33	0.32	0.25	0.44	0.31	0.36	0.34	0.30	0.14	0.29	0.32	0.26
3	0.25	0.30	0.45	0.20	0.36	0.44	0.44	0.34	0.21	0.12	0.27	0.31	0.30
4	0.19	0.27	0.55	0.17	0.30	0.54	0.51	0.34	0.16	0.11	0.26	0.31	0.32
5	0.33	0.32	0.35	0.31	0.31	0.37	0.36	0.33	0.31	0.23	0.33	0.24	0.20
(c) 6	0.28	0.27	0.45	0.24	0.30	0.46	0.45	0.34	0.21	0.16	0.32	0.29	0.23

Fig. 6: Scenario 1: (a) Evidence; (b) Instantaneous Estimations; and (c) Adapted Estimations

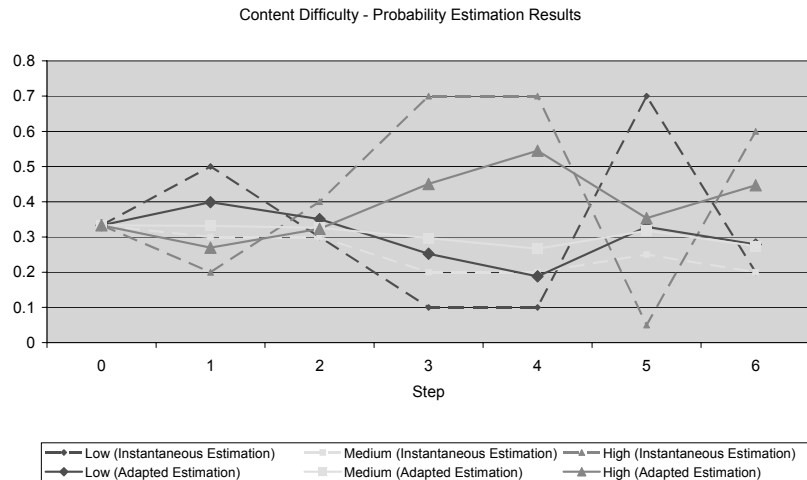


Fig. 7: Scenario 1: Estimation results for the Content Difficulty

As an indicative example of this behavior, let us observe the estimation results for the Content Difficulty parameter, at steps 4 and 5. At step 4, we may observe that the adapted estimation indicates High as the most probable value. However, at step 5, a radical change is detected at the evidential data. According to the instantaneous estimations, Low is by far the most probable value at step 5. However, the adapted estimation takes into account the historical knowledge, by moderating this oscillation, and suggests again High as the most probable value; this time, of course, the probability of value High has significantly been decreased. This gradual adaptation to the evidence allows the system to avoid temporary and impulsive oscillations.

VI. SUMMARY, CONCLUSIONS AND FUTURE WORK

As already noted, nowadays the demand for services through computer networks has increased remarkably, as e-services are gaining constantly ground in the field of telecommunications. Consequently, users are getting more demanding regarding the services offered to them. On the other hand, we will also have to take into account users that are not so accustomed to using computer devices and thus need simple and practical services to be delivered to them. For these reasons we have introduced cognitive networks, which aim at making the part that users interact with more comprehensible and easy, hiding from them network's complexity. Along with this, it is necessary for the service to be able to manage information provided by users and provide the system with the cognition of the way it will have to be configured so as to meet users' needs. For the validation of

this vision we presented Bayesian Networks and the way they can manage and effectively predict the values of certain parameters of the User Model in a Learning Management System, in order to predict users' future preferences and thus develop the content. This was also certified by a simple but realistic scenario we presented in brief. Such prediction shall be done in every aspect of e-services, in order to achieve the management of a more advanced service delivery, which will most likely lead to a more massive e-services usage.

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Management Architecture for the Provision of e-Services in Cognitive Environments

Y. Kritikou, P. Demestichas, G. Dimitrakopoulos, F. Paraskeva, *University of Piraeus – Department of Digital Systems, Greece* kritikou@unipi.gr

A. Kyriazis, *University of Piraeus, Greece*

M. Paradia, *Ministry of National Education and Religious Affairs, Greece*

N. Mitsis, *University of Thessaly, Greece*

Abstract—The following paper discusses on the evolution of cognitive networks in conjunction with the development of advanced e-services, making a brief description of their role in modern society. E-services are delivered through a specific model, which is described in detail, and find several applications in peoples' everyday activities. E-learning has proven to be a very important application of e-services, since the number of users that adopt it in their lives increases everyday. Thus, this paper presents the architecture of an e-learning platform, as well as the principles of the learning theories that influence the content's structure. In this work, the e-learning content is formed for use by adult learners. Finally, the need for adaptation to each user's specific demands and preferences, concerning both the content and the technical features of the platform, is discussed, providing further information on the way this personalization can take place, so as the maximum performance of users can be achieved.

Index Terms—adaptation, cognitive networks, e-services, e-learning, user profile

I. INTRODUCTION

THE world of wireless communications has numerous achievements to demonstrate nowadays, one of them being the tremendous evolution of wireless communications. Research

in this field has been rendered mandatory, due to the ever-increasing user requirements to seamlessly access the internet anywhere and at anytime. The development of wireless networking potentials is depicted nowadays on the advent of cognitive networks. Cognitive networks comprise disparate Radio Access Technologies (RATs) that can reconfigure themselves, in order to respond to stimuli and thus adapt to environment-originated requests.

This means that users in a cognitive environment will be offered the ability to access innovative services at high bit rates, compared to those offered by wired networks. Such services, namely e-services aim at making users' lives easier, saving them time and effort. A typical representative of e-services is e-learning, which everyday gains ground in the field of education through telecommunications.

However, e-services also call for an appropriate infrastructure that will cater for their faultless provisioning.

Aligned with these thoughts, this paper deals with how to manage the provisioning of e-services in a cognitive radio context. For this purpose, the following section (Section II) makes in short a presentation of cognitive networks' evolution, which has resulted to the development of e-services. Section III contains a brief overview of e-services and discusses on the general system, through which e-services are delivered. Section IV focuses on e-learning, an application of e-services, and presents the principles of two learning theories, which study the way adults learn and how the learning material should be structured in order to result to effective learning content. The architecture of such an e-Learning Platform (referred as Learning Management System, too) is also analyzed in this section, while in Section V a particular element of the e-learning platform, the User Profile element, is described. Finally, Section VI provides the Conclusions, as well as the Future Work to be done in this field in order to create an e-learning platform able to predict and adapt to each user's personal needs and preferences.

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Yiouli Kritikou, Panagiotis Demestichas, George Dimitrakopoulos and Fotini Paraskeva are with the University of Piraeus, Department of Digital Systems, Karaoli and Dimitriou 80 Str, Piraeus 18534 (Telephone number: +30 210 414 2749, +30 6944 518 685, e-mail address: kritikou@unipi.gr).

Athanasios Kyriazis is with the University of Piraeus.

Maria Paradia is with the Ministry of National Education and Religious Affairs.

Napoleon Mitsis is with the University of Thessaly, Department of Primary School Education.

II. THE EVOLUTION OF COGNITIVE NETWORKS

Enormous investments are being placed on research efforts targeted at the design of novel communications systems. Currently, the wireless communications landscape comprises mobile systems, wireless local/ metropolitan area networks, wireless personal area networks and short range communications, as well as digital video/audio broadcasting systems. An even more recent trend consists in the cooperation of those Radio Access Technologies (RATs) and their cooperation over a common access infrastructure, namely the B3G (Beyond the 3rd Generation) wireless infrastructure. This work is targeted at delivering highly-sophisticated services, cost – effectively [25].

A facilitator of the B3G vision is the advent of cognitive networks [26], which are able to reactively or proactively respond to external stimuli and thus adapt to environment requisitions. Adaptation is mainly realized by means of self-configuration, i.e. (re)configuration of the systems' own infrastructure. In this way, users will be able to seamlessly access disparate services (the so called e-services) and applications, saving time and effort. On the other hand, intelligent engineering techniques are required, in terms of management functionality that will direct the overall reconfiguration process (through cognition). Aligned with this, a significant question arises on how to manage the different users that wish to access a specific e-service in a cognitive radio context, which is the main focus of this paper.

The next section presents briefly the evolution of e-services, the role they have in peoples' lives and the system used in order they can be effectively delivered to users.

III. OVERALL VIEW OF E-SERVICES

A. E-Services

The last years have witnessed an explosion of activity around electronic services (e-services) in science and telecommunications in particular. In general, the fundamental objective of e-services is clear; to have a collection of network-resident software services accessible via standardized protocols, whose functionality can be automatically discovered and integrated into applications or composed to form more complex services [1].

However, to take things from their start, e-business and e-commerce are the ancestors of e-services. The idea was to conduct business over the Internet using any of the applications that rely on the Internet, such as e-mail, instant messaging, shopping carts, etc [2]. E-services, a business concept developed by Hewlett Packard (HP), encompasses the idea that the World Wide Web is moving beyond e-business and e-commerce into a new phase, where many business services can be provided for a business or consumer using the Web. HP defines e-services as "modular, nimble, electronic services that perform work, achieve tasks, or complete transactions"[3].

Apart from e-business and e-commerce, the concept of e-services embraces day by day even more services, in order to

complement different parts of peoples' lives, aiming to facilitate and accelerate the procedures of their daily life. More specifically, e-services include e-work, e-health, e-banking and e-learning. This list is continuously enhanced as peoples' needs increase. Someone may say that e-services are becoming day by day an integral part of peoples' routine, as graphically depicted in Fig. 1.

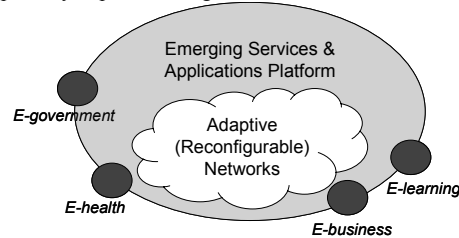


Fig. 1 E-services in the context of cognitive networks

B. System of e-Service Delivery

In this context, we need to identify a system, which describes the way e-services can be delivered effectively. More particularly, this system consists of Services, Infrastructure and Users.

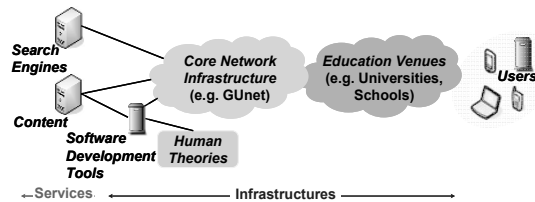


Fig. 2 A general system for the delivery of e-services

Services include search engines and content. The content is one of the most important components of the system, as it includes the material to be presented to the users. In order to satisfy each user's unique demands, the content will have to be structured and personalized according to different needs and individual styles of each user. Personalization of the e-Services is the way to make them more attractive to the users and consequently more useful for them, as the chances of making it a part of their daily routine increase at a great extent. Search engines, on the other hand, seem to have become a pretty practical tool for users, assisting users in searching and finding e-services, which till now they did not have a way to find, or even ignored their existence. These search engines may be either already existing software (e.g. Google, Yahoo! or Lycos), or provided to the system by the software developers.

As aforementioned, the content of the system has to be advanced and well-structured, in order to meet users' needs and satisfy their expectations for services, and the platform will have to be accessible just by connecting with their personal device to a network, as well. For this to be achieved, Software Development Tools are necessary, as they offer the

developers the ability to form the content according to users requirements and special needs and enhance it with special, advanced features, needed to create robust e-services. This means that Software Development Tools are also influenced by human theories (such as theory of human nature [20], theory of human development [21], theory of human motivation [22], theory of human learning [23], etc.) which differ according to the type of e-service applied each time, aiming at delivering advanced service, regarding both the technical features of the platform and the content of the platform.

The second part of the e-services system delivery is Infrastructures. Infrastructures comprise of Core Network Infrastructure and Education Venues. In fact, Infrastructures provide the mechanism by which the e-Service is delivered to the users. Core Network Infrastructure is the means by which information, i.e. an e-service, reaches the terminal device of each user. In other words, Core Network Infrastructure provides the network, wired or wireless, through which the requested information is transmitted. The necessary research, the tests and the pilot implementation of every new e-service aimed to be developed, take place in Educational Venues. In such venues, researchers work on different scenarios and take in mind several factors, in order to evolve beneficial and worthy e-services. Undoubtedly, without Infrastructures the development of e-services could not be enforced and no communication between the two parts, Services and users, would be possible.

Of course, Users could not be omitted, as without having someone to use it, a system and consequently a service would have no reason of existence. Thus, using the network infrastructure and their personal device (i.e. a PC, a PDA, a laptop or a palmtop) users can easily access the service that will help them proceed with a specific task they wish to accomplish.

Taking in mind the previously described system, the following sections aim at describing the necessity for the creation of an e-learning platform, in order to deliver to users personalized courses. The following section makes a brief discussion on the learning theories, their principles and the way they are used in forming the e-learning material to be presented to users.

IV. LEARNING THEORIES AND E-LEARNING PLATFORM

A. Learning theories

Before analyzing the learning theories, we have to take some things as a fact; this paper refers to e-learning courses aimed to be used by adults and the e-learning platform is meant to be accessible not only through wired, but also through wireless networks, which means that the platform will have to be equipped with cognition, in order to be able to adapt to users' unique preferences.

In a general context, learning can be defined formally as the act, process, or experience of gaining knowledge or skills [4]. As previously mentioned, e-learning occurs if the learning

procedure is facilitated and bolstered up by information and communications technology. On the other hand, when having to deal with adults' learning with the aid of electronic devices and computer networks, things become more complicated.

A Learning Theory provides the designers with specific guidelines regarding the structure of the learning material. In this paper we discuss on two of these theories, Situated Cognition and Cognitive Flexibility Theory, as they seem more appropriate for the type of educational platform we aim at developing.

Situated Cognition (or Situated Learning) was first expounded by Brown, Collins and Duguid. Situated cognition is a powerful metaphor for human learning, authentic learning experiences and cultural influences [5]. Its principles are based on the idea that adults find it difficult to return to the classroom in order to increase their knowledge. Instead they prefer having access to the learning material from their home, their office, and even better on their way to work. Thus, the learning content will have to be provided in a context familiar to users, saving their time and effort, rather than being in a specific place on a predetermined time. What's more, situated learning supports that the learning material provided to users is essential to have certain characteristics in order to be more effective and fulfilling. At the outset, it is necessary to transfer knowledge in real life situations, giving examples of the newly introduced concepts. During the learning procedure, the student needs to be encouraged by the instructor to overcome any problem he encounters and he wants to be able to interact with other students, in order to exchange ideas and expose different point of views of a problem. Summarizing the above, we may say that situated cognition intends to create a situated learning environment, which attempts to help students improving their cognitive abilities, self monitoring and self-correcting skills, encouraging active learning and providing opportunities to internalize information [6].

Another learning theory that acts complementary to Situated Cognition is Cognitive Flexibility Theory (CFT) first established by Spiro [7]. He suggested that people acquire knowledge in ill-structured domains by constructing multiple representations and linkages among knowledge units [8]. This can be achieved by designing hypermedia documents that present multiple cases where similar concepts are linked across cases [9].

More specifically, Cognitive Flexibility Theory concerns the transfer of knowledge and skills after the initial learning situation. At first, students learn the basic concepts, theories, etc. in a linear context. However, when advanced knowledge acquisition occurs, a non-linear approach is mandated to accommodate the ill-structured domain in which the learning occurs. Thus, information must be presented from multiple perspectives to simulate diverse examples of the application of fundamental concepts [10].

A combination of the principles of the aforementioned learning theories can be determinative in structuring the learning material. The fact that this material is delivered through the network and thus there is asynchronous support

by a teacher or an instructor should by no means slip our mind [27]. Consequently, the material will have to be as effective, scaffolding and stimulating as possible.

B. E-learning platform architecture

For e-learning services to be delivered, a learning platform is necessary to be developed, which facilitates users' access to the learning content. The online educational platform provides a supportive tool during learning and aims at being strictly consistent with the theoretical principles and the needs of the users, so that it could meet their needs. Special emphasis is given on producing an 'educational product', "taking into account both tangible and intangible aspects of the educational process, such as choosing the appropriate supportive linguistic material, providing the right motivation, the interaction between learners, the improvement of their performance and the development of their skills during the teaching process" [11]. In order to achieve these goals all tools and the material used during the educational process should meet the pedagogical standards set, so that the desired didactic goals could be realized, as also mentioned in the Section 3.1.

In this section we present a general form of architecture of an e-learning platform, as concluded through several studies made upon this matter [12], [13], [14], [15], [16], [17], [18], [19].

As depicted in Fig. 3, the architecture of an educational platform comprises five basic elements, which constitute an integral part of the platform. More specifically, these elements are: Domain Model, User Profile, Tests and Deliverables, Student Evaluation and Activities. The Domain Model's role is to collect and store the educational material, making it easier to the Management Platform to retrieve and form it according to user's requirements. In the User Profile the system stores information regarding users' preferences and needs, as well as log files for users' context features and their previous behavior in the system. Activities have to do with exercises the user takes during his navigation in the system, while Tests and Deliverables concern the tests and the essays the user fulfills, when finishing a lesson or section of the course.

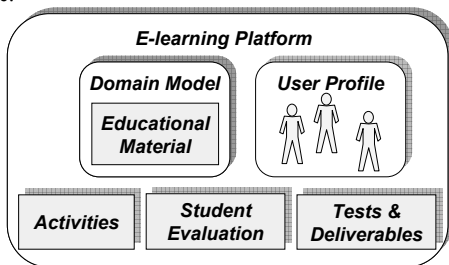


Fig. 3 The architecture of an e-learning platform

V. USER PROFILE

The User Profile is responsible for keeping information concerning users in a general sense. More particularly, the

User Profile keeps records for each user separately, in order to be in position to provide this information to any of the other elements of the platform when requested. The data kept in the User Profile have to do with each user's personal information (i.e. his name, his age, etc.) the courses he is mostly keen on and the material he has already accessed. In this way, the system is able to conclude what is level of knowledge the student is at, characterizing him as novice, intermediate or expert. This will further influence the learning material to be presented to the user. What's more, the User Profile is the system's element which keeps records on user's behavior in the system, statistical information regarding user's history and information on the sequel of the courses he took during his navigation in the system (learning path [24]). Also, data concerning the context, and more specifically the equipment/device and the technology (wired or wireless connection) the user usually uses to access the platform, are also elements stored in the User Profile.

The information kept in the User Profile element has a great impact on the information the system decides to provide the user each time he inquires about a specific material. This means that the User Profile will have to be attributed with a set of parameters, aiming at configuring the content to be delivered the user. This configuration takes place in order to achieve adaptation to each user's needs and expected outcomes, both concerning the e-learning material and the technical features of the communication between the platform and the user's terminal. Of course, it should be expected that these parameters will dynamically change, as the user moves on with the courses he has selected to be delivered to him.

Taking these factors into account, we come to the conclusion that so as to achieve correct content configuration and delivery, it is essential for the User Profile to be enhanced with a certain point of cognition. In other words, it is imperative that we equip the User Profile with a certain mechanism able to collect information, plan, decide and finally act upon the collected information.

The necessity for the creation of a specific mechanism responsible for collecting, processing and deciding upon the material to be distributed has come in the foreground. The solution to this matter is the Management Functionality entity, whose goal is to aid the Learning Management System make the correct decision on the content to be delivered to each user.

The next section provides the conclusion as well as the future work needed to be done in order to proceed to the creation of such an e-learning platform.

VI. CONCLUSIONS – FUTURE WORK

E-services undoubtedly gain ground in peoples' routine, as they continuously achieve to simulate more and more activities, which till now required their physical presence. Cognitive networks contribute a great deal to this fact, as they facilitate e-services delivery. This creates also many challenges to the designers, the programmers and the

developers of such services, as users become even more demanding and selective about the way e-services are provided and the needs they cover.

Consequently, it is essential that the e-services offered to users enhanced with very advanced features, aiming at becoming an integral part of their lives. Adaptation to each user's personal needs and preferences seems to be the next step for e-services. This extra feature will enable users only by registering to the specific e-service platform to have access to personal data, collect information they require by only a few clicks, without having to wait to long queues and wasting their time on their way to or in the public services.

More particularly, an e-learning platform is going to be in position to provide users the information that is of their interest, based on previously accessed content. This means that the network and the platform itself will be in position to know the identity of each user, his previous activity in the system, as well as to predict the potential information the user wishes to see. A lot of research has been already done in this issue and soon there will be a realization of this venture, as both parties, users and developers, will be benefited at a great extend.

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e-Learning techniques in IT programs *are they helping my sense of cyber-ethics?*

Zeenath Reza Khan
University of Wollongong in Dubai
PO Box 20183 Dubai UAE
Email zeenathkhan@uowdubai.ac.ae
zrkhan@eim.ae

Abstract

With the boom in technology, it is not surprising to see high-tech tools implemented at most schools and colleges to enhance the total learning experience for the students of the twenty-first century. From up-to-date software, hardware and online tools, electronic learning has becoming somewhat of a 'fashion' where most tertiary academic organizations are concerned. World-wide, academic bodies are competing to develop and implement the latest, advanced tools to gain advantage over peers across the globe, to give their students a better learning experience, to improve their resumes and ultimately earn millions.

Universities and schools all over the world are opting to include at least one element of e-learning in every field of study, be it medicine, business, law or information technology itself. From WebCT to Netmeeting to the basic computer on-line and offline applications, every electronic system that has a potential to be used as a whole or part of e-learning is already being used in some form or the other in and out of classrooms. Where students are being taught using these tools, it does not seem clear if they can distinguish between e-learning and *e-cheating*. Or can they?

This paper looks closely at the gap that exists in students to distinguish between e-learning and cyber ethics. It tests student awareness of e-learning tools and how these are affecting their sense and perception of ethics. The paper ends by proposing suggestions to include subjects or courses that highlight the difference between e-learning and *e-cheating* in order to arm students with the necessary understanding to increase their awareness to ethical issues and thus become potential value-added professionals, and thus opening the door to further study in this area.

I. INTRODUCTION

As a law of nature, man has an insatiable thirst to gain knowledge, be it from his surroundings or his peers. Whatever the source of information, the mode of delivery seems to be just as important. Because nothing in life is static, man's perception of learning is changing with time. The process of teaching and learning seems to be ever evolving to suit the changing student body, their level of intelligence, attention span, era they are living in and so on. At every corner of the globe, teachers and researchers are working hard to find new ways to get the required

knowledge into the students in fast, effective ways that catch their attention, add value to their learning process and increase their potential as employees. Although the conventional classroom existed since the beginning of civilization, it is in the recent decades that the focus has shifted from what is being taught to how it is being taught. E-learning is a fruit of this shift. E-learning, according to Derek Stockley, is the delivery of a learning, training or education program by electronic means; involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material [8]. There are so many e-learning tools, to the point where almost any and every computer or electronic device or software used during or for teaching purposes are now considered to be e-learning tools, that listing them is virtually impossible. Online learning is not the next big thing; it is the now big thing. - Donna J Abernathy [2].

Because learning is a social process [10], it is easy to see why e-learning tools have gained the popularity in and out of classrooms in the twenty-first century. Tools such as Blackboard, WebCT and so on 'encourage student collaboration; improve team working skill and independent thinking' [1]. Added to this is the peek of the technology era that has revolutionized conventional teaching into twenty-first century learning via mobile phones, chat rooms, on-line discussion boards, and many more.

But, what is the impact of all this on the students' perception of ethics? How does it affect their sense of professionalism when they join the work force?

This paper looks closely at the possible dual-effects of e-learning on impressionable minds and the follow-on clash it creates in their sense of ethics.

II. E-LEARNING IN UNIVERSITIES

Almost every tertiary level academic organization has implemented some aspect of e-learning into their curricula, be it for business or information technology courses. From internationally renowned Harvard University in Boston (USA) to

local universities such as Higher Colleges of Technology in the United Arab Emirates (UAE), almost every classroom is equipped with high-tech hardware and software to carry on e-learning with ease. These include projectors, laptops with wireless networking to access the Internet, and so on. At the University of Wollongong in Dubai (UAE), the annual Dean's symposium on Excellence in Learning and Teaching in May 2006 focused on e-learning. Representatives from around the region discussed and demonstrated examples of actual e-learning practices in higher education institutions. From teaching methods to assessments, e-learning tools have infiltrated the academic world with accelerating force. Role plays are being carried out online across continents, students are meeting and discussing concepts over discussion boards and other online meeting arenas, teachers are sharing files over WebCT, lectures are being transmitted as mp3 files over the internet via video conferencing or as downloadable files [1].

A lot of time and money has been spent on researching into the effects of e-learning on higher education. Organizational structures of universities are transforming to adjust [7], organizational strategies are changing [3] and even the roles of teachers or lecturers have been reviewed [6], [9]. Research has also been carried out to study the impact of e-learning on students' over-all grades [4]. However, little or no research has been carried out to study the impact, if any, of e-learning on the students' perception of cyber ethics.

To study the possible effects of e-learning, face-to-face interviews were carried out on 110 students from three different universities situated in the United Arab Emirates. Table 1 shows the Universities' backgrounds and curricula summary.

TABLE 1: SUMMARY OVERVIEW OF THE THREE UNIVERSITIES TARGETED

University 1	University 2	University 3
Direct campus of western university	Local university	Local university, affiliated to western university
Accredited by UAE Ministry of Education ¹	Accredited by UAE Ministry of Education	Accredited by UAE Ministry of Education
Over 2000 students	Over 4000 students	Over 1000 students
Multicultural student population	National men students only	Multicultural student population
Implemented E-learning tools to all disciplines	Implemented E-learning tools to all disciplines	Implemented E-learning tools to all disciplines

Students interviewed were chosen in random in terms of age, gender and year of program. All respondents were students of Information Technology.

¹ Ministry of Education in the United Arab Emirates has in place a system of accreditation whereby Universities are judged as per international standards by bringing in expert panels from around the world. Universities once accredited have to be reevaluated every two-three years and adhere to the requirements.

Personal interviews were conducted under controlled environment, in a quiet room, with the interviewer (appointed by the author) and the students, one at a time. Each interviewer was given a list of questions to ask and ticked the answers on a five-point Likert scale. This method saved time and generally received a more friendly response from the students than handing out questionnaires where students tended to chuck it into the dustbins or simply tick the most accessible answer.

The questions on the list ranged from testing students' knowledge on E-learning definitions, and tools to whether they were being used in the class rooms. Certain simple situations that distinguish between ethical and unethical situations were put across as well to test student awareness. The results² were tabulated using weighted average (ref Appendix A) for each category of question and summarized as illustrated in Table 2.

III. EFFECTS OF E-LEARNING TOOLS ON STUDENT PERCEPTION OF ETHICS IN IT

Evaluating the interview results along with personal follow-up phone calls to certain students reaffirmed the author's hypothesis that there indeed exists a gap in students' minds where e-learning tools and e-cheating is concerned. Looking closely at Table 2 and Graph 1, it is clear that although all the IT students come from a system where e-learning tools have been implemented and are used rigorously, they are not very clear on the actual definition of e-learning or the tools. When asked if 'E-learning is only online applications used to teach and learn in a classroom', majority of the students 'strongly agreed' bringing the weighted average down to a 1.42. On the other hand, 'Mobile phones and chat programs are tools of E-learning' scored only a 2.17 as only 2 students 'strongly agreed' demonstrating the students' lack in knowledge as far as e-learning and its tools are concerned. The next few categories tested the students' perceptions of e-learning to what is allowed and ethically correct and what is not. Where students thought it was okay to download lectures from online classroom folders, they also thought it was okay to download music and movies. In consequent phone interviews, students mentioned they felt 'it was the same thing; if we are allowed to download the lectures, why not the songs and movies which are available for free'. Similar opinions were expressed where chatting and sharing documents were concerned. In general students felt if they were allowed to chat to discuss tutorial work, they should be allowed to chat with friends about outside affairs. Or that, if they were sharing folders and downloading files and using notes from one another over discussion boards, it 'was the same thing when using the information in their assignments'.

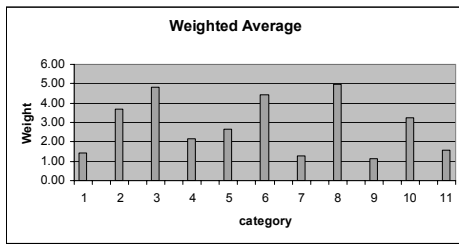
² Details of the method and results were not included in this paper due to space constraint; however, weighted average is explained in Appendix A.

TABLE 2: SUMMARY RESULTS

		strongly agree	agree	neither agree nor disagree	disagree	strongly disagree		weighted total	weighted average
1	E-learning is only online applications used to teach and learn in a classroom	81	15	11	3	0	negative	156	1.42
	Weight	1	2	3	4	5			
2	E-learning is any computer application used to teach and learn in and out of classrooms	43	21	19	22	5	positive	405	3.68
	Weight	5	4	3	2	1			
3	WebCT, Blackboards are examples of E-learning tools	92	18	0	0	0	positive	532	4.84
	Weight	5	4	3	2	1			
4	Mobile phones and chat programs are tools of E-learning	2	7	22	56	23	positive	239	2.17
	Weight	5	4	3	2	1			
5	If I share files over WebCT, it is not plagiarism	23	5	15	47	20	positive	294	2.67
	Weight	5	4	3	2	1			
6	If I discuss my paper over chat is not plagiarism	79	19	0	2	10	positive	485	4.41
	Weight	5	4	3	2	1			
7	If I do group work over the net, then copying and pasting from other work is not plagiarism	100	1	0	4	5	negative	143	1.30
	Weight	1	2	3	4	5			
8	If I download mp3 files for class work from subject folders it is not copyright violation	108	2	0	0	0	positive	548	4.98
	Weight	5	4	3	2	1			
9	If I download mp3 songs and movies it is not copyright violation	98	11	1	0	0	negative	123	1.12
	Weight	1	2	3	4	5			
10	If I chat for fun and not about school work during tutorials it is not unethical	16	21	5	57	11	negative	356	3.24
	Weight	1	2	3	4	5			
11	If I chat for fun and about school work during tutorials it is not unethical	69	31	3	0	7	negative	175	1.59
	Weight	1	2	3	4	5			

This was clearly illustrated in the interviews where 100 students 'strongly agreed' that 'If I do group work over the net, then copying and pasting from other work is not plagiarism' and 69 'strongly agreed' to 'If I chat for fun and about school work

during tutorials it is not unethical' and a whopping 108 to 'If I download mp3 files for class work from subject folders it is not copyright violation'.



GRAPH 1: SUMMARY OF RESULTS IN A BAR GRAPH.

This clearly shows the kind of confusion that seems to exist in students' minds where e-learning and cyber ethics is concerned. The various tools used for e-learning seem to some how cloud the judgment of students and as there seems to be a lack of prior knowledge (education) that can clearly distinguish between e-learning and e-cheating, this has caused students' perception of ethics to be distorted in certain areas.

IV. CONCLUSION

Discovering, evolving, enhancing and adopting are all reasons why man moved through so many different and varied eras from ice age to the information age. However, through it all, one thing has held man apart from the animal world – values and attitudes that govern the societies and applies constraints to distinguish between right and wrong. But what happens when something that is supposed to help, actually hinders this distinction?

E-learning has definitely been a boon to the process of teaching and learning as has been proven by so many researchers in the past. However, the dual effect it is currently having on the students of the twenty first century is not something anyone forecasted. Where any form of learning should help develop a sense of responsibility and professionalism in the students, many e-learning tools are doing the opposite. This is mainly because almost every computer application has become a part of e-learning process and therefore students are having difficulty realizing why it is okay to use them for one thing and not for another.

As it is beyond the scope of this paper, based on a previous study by the author where research proved that education bridged the gap between ethics and professionalism "in press" [5], it is recommended that universities that practice e-learning and e-teaching impose or include some components of cyber-ethics that clearly distinguish between e-learning and e-cheating (an area that is currently being researched by the author for a subsequent paper).

V. APPENDIX A

Calculating the weighted average:

In Table 2, for each Likert Item, there is a 'weight' placed depending on how close the choice is to being right. For instance, for the question 'E-learning is only online applications used to teach and learn in a classroom', the weights start from 1 to 5 for each of the Likert items 'strongly agree', 'agree', 'neither agree nor disagree', 'disagree', 'strongly disagree' respectively. This is because if a respondent chooses 'strongly agree', he/she demonstrates vague knowledge of what e-learning really is. For another question, 'If I download mp3 files for class work from subject folders it is not copyright violation', the scale is reversed such that if a respondent chooses 'strongly agree', the response receives 5 point on the scale thus showing he/she has chosen the right answer. Once the weights have been placed on each response, the average is calculated by totaling response for each question and dividing by the total number of respondents for each question (110 students) in each case).

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E-LEARNING BASED DISTANCE EDUCATION AT SZECHENYI ISTVAN UNIVERSITY

Z. Letray – M. Kovacs – L. Nyeki
Szechenyi Istvan University
9026 Győr, Egyetem ter 1.
Hungary

Abstract: The paper describes our experiences of e-learning based distance education of transport engineer, engineer manager and economist students.

I. INTRODUCTION

Széchenyi István University has introduced e-learning based distance education in autumn 2004 firstly for transport engineer, one year later for economist, and this year for engineer manager students. The training is based on the Coedu named e-learning system shell of Mimoza Communications Ltd. Curriculum development is based on their Coeditor software. The members of the curriculum development team are the instructors of Department of Teacher Training. Students get the curriculum in online, CD-ROM and PDF formats. The personal preparation of students is assisted with study schedules. According to our experiences school achievements are better than in traditional distance learning.

II. CAMPUS NETWORK ARCHITECTURE

At the University a high level IT infrastructure is available: Ethernet LAN 100 Mb/s, and proper server resources for web-based e-learning solutions (Fig. 1).

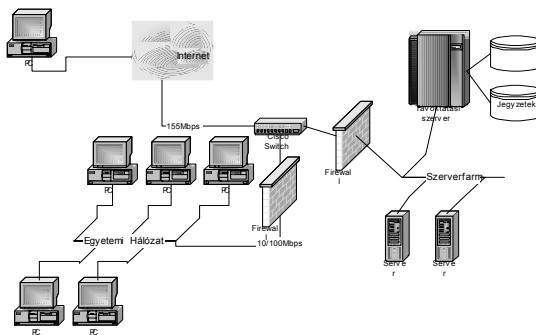


Fig. 1. Campus network architecture

We have realized that a reliable, robust and powerful computer network infrastructure is inevitable, so we have built an advanced Cisco solution for the on-line Internet/Intranet access.

III. SELECTION OF AN E-LEARNING FRAMEWORK

We have examined the “big names” (Learning Space, iLearning etc.), but we faced problems like:

- heavy HW/SW requirements,
- customizing into Hungarian (language and education system) is a hard job, or can be only partly done,
- only “upper” level, “general” support is offered,
- relatively expensive products for an educational institute.

In addition, under the actual application a huge, robust base-SW system must run, and this raises the operating expenses.

In finding the optimal solution, we have declared some crucial requirements:

- opportunity to influence the requirement specification and functionality (in between development),
- direct (“personal”) help-desk, quick response, intensive support and training at the introduction phase,
- reasonable price for licenses and for the yearly support.

We have examined some Hungarian products and finally, we have chosen the COEDU system of the Mimoza Communication Ltd.

IV. THE STRUCTURE OF THE COEDU SYSTEM

Coedu system is the most frequented distance learning application used in Hungary; it is equally used in public education, in higher education and in adult education.

The Coedu system has four parts (Fig.2):

- The course administration subsystem
- The course editor subsystem (Coeditor)
- The course displayer subsystem
- The course management subsystem

With the course editor we can make XML-based e-learning curricula. The editor is capable to generate SCORM 1.2 compatible courses. Courses are built from modules, and modules are divided to lessons.

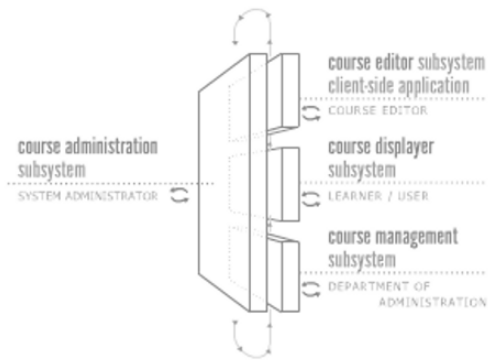


Fig. 2 The structure of the Coedu system

In the Coedu system there are the following right permissions:

- system administrator
- curriculum developer
- study administrator
- tutor
- student

The system administrator has the most general right permissions. He can define user groups, can give them predefined right permissions and can handle courses under construction.

A curriculum developer can generate an empty course, can clone and rename a course. A curriculum developer is able to test courses which are not reachable for students. A curriculum developer can download an empty course from the server, and can fill it with subject matter. He can upload the ready course to the server. A curriculum developer can generate the PDF and the offline version of the course. The PDF version is for students who prefer printable subject matter, the offline version helps in the case of slow Internet connection.

A study administrator can manage student groups. He gives the startup and expiration date of a course, and he can give a tutor for a student group.

Tutors can send messages to students. They can observe the studies of students, because the tests at the end of a module are logged in the system. The tests at the end of a lesson are not logged, their purpose is self control. Tutors are evaluating the answers to open-ended test questions too. The answers to other test question types are evaluated automatically.

Students can study online or offline. They can use the built-in Forum of the Coedu system to chat with each other, or they can send personal messages in e-mail to the tutor. The chat Forum service is broadly used to talk over study problems.

In the recent stage of development the Coedu system has not yet a test item bank. So tests are constructed manually.

V. THE COEDU COURSE EDITOR

In the recent state in the Course Editor the curriculum developers can select English, Hungarian and Russian language. The File menu of the Course Editor has the usual functions (Fig. 3). Developers can open, download, upload, save courses. They can migrate to an other server, can work offline, and can export the course in SCORM 1.2 and Oracle format. The Edit menu has a refresh and an undo function. The Options menu gives possibilities to set the server, the language, the proxy, etc. The Help menu gives information about the version number of the editor. There is no built-in Help yet.

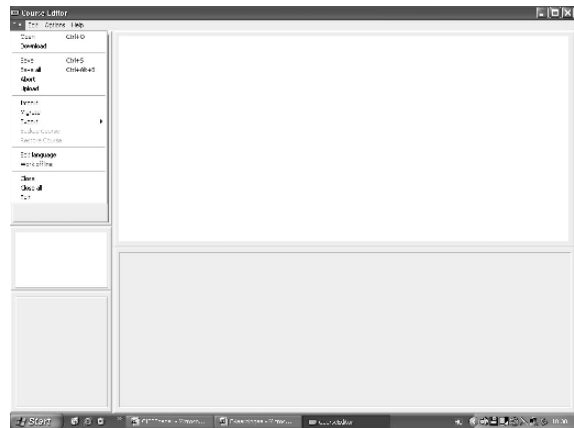


Fig. 3 The File menu of the Course Editor

As we have mentioned before, the Course Editor is XML based. It stores lessons in separate XML files, and the course has a common XML file listing the lessons of the course. All courses are stored in separate folders.

The language of the courses is selectable. There are nine possibilities now (English, Hungarian, Russian, German, French, Spanish, Greek, Italian and Finnish).

Math formulas can be written with a simple integrated editor. Formulas can be inserted in JPEG and MathML format. Formulas can be copied from the editor to the clipboard, and from the clipboard the MathML code can be pasted as a formula to the Course Editor.

Of course we can insert images, animations and videos to the lessons. We can use normal images, zoom images, flipbooks (a predefined chain of images), and timelines too. The subject matter has three selectable representations (contracted,

normal and enriched) according to the current needs of the student.

The working surface of the Course Editor is shown on Fig. 4.

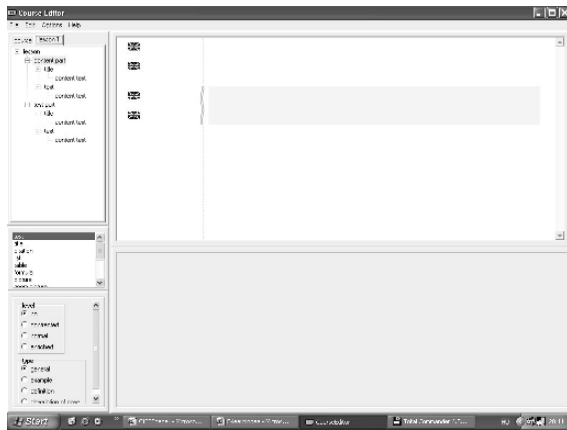


Fig. 4 The working surface of the Course Editor

The upper left frame is the editor tree. The developer can insert to the tree modules, lessons or parts of a lesson. The middle left frame shows the selectable parts of the lesson. The lower right frame offers the selectable languages. The upper right frame is the visible part of the lesson, as is. The lower right frame is the input text window, if it is active.

VI. VISUAL ELEMENTS IN THE COEDU SYSTEM

Visual elements are playing an important role in understanding the subject matter. We can import visual elements as external files to the system. It means, that we have to prepare them outside the system using an other application.

A picture is the simplest visual element. A zoom picture is composed of two images, one is a normal image, other is a big image, which on a mouse click opens in a pop-up window.

The viewer picture consists of a big image field and at the bottom of it more little images. Moving the mouse cursor upon a little image, we can see the big pair of the image.

A flipbook serves the understanding of a process. It is composed from more picture elements, these can be viewed by the user in succession by means of an arrow (Fig. 5).

A timeline is similar to the flipbook; we can present with it a temporal process (we have to associate with every picture element a moment).

The inline picture is a small image, it is used to insert a Greek letter, an icon or a button of some software.

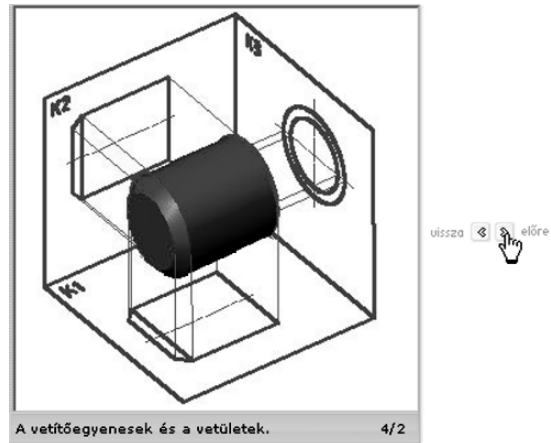


Fig. 5 A flipbook

Flash and video objects are used to join interactive images, simulations, small films, cartoons to the content matter. The system starts the default media player on the computer of the user, and presents the file. After viewing the user has to close the window of the media player.

VII. CURRICULUM DEVELOPMENT

In the course of instructional design we start out of existing lecture notes, textbooks and course syllabuses. We analyze the requirements of the course, and explore the existing paper-based midterm and exam tests. Relying upon these findings we determine the detailed requirement system of individual subjects. The detailed requirement system forms the basis of preparing electronic curricula and study guides.

We prepare a study guide if there is a modern, well usable textbook. If a textbook is outdated, or is not accessible, then we prepare a complete electronic curriculum. In this case is not necessary for students to use a printed textbook.

The structure of study guides is uniform. We divide the course to modules, and the modules to lessons. The modules are corresponding to the chapters. The lessons are logic units, the extent of the lesson is such, that a student can study it during one, one and a half hour. The lesson begins with learning objectives, the second part is the methodological guidance for student activities, the third part is the summary. At the end of every lesson there is a test for self control. This test is not scored, so it is solvable in online mode more times. The solutions of unscored tests are not logged in the system.

The lessons of a complete electronic curriculum differ from the lessons of the study guides. They does not refer to the pages of a printed textbook, because they contain the subject matter too. So the lessons of complete electronic curricula generally do not contain a summary.

At the end of the individual modules there are module closing lessons. These are scored tests, so they can be solved only once. The scores are logged in the system, so the tutor can trace the progress of students.

The tutor can determine from the student records, which parts of the curriculum cause study difficulties. The module closing tests are similar to the exam tests, we want to help with this the preparation of students.

Curriculum development is made in group work. The members of the Curriculum Development Group are generally the instructors of the Department of Technical Teacher Training. In the development of the study guide of a subject participates the instructor responsible for the subject (who is selected by the department responsible for the instruction of the subject), the curriculum developer and the digitizer.

The digitizer converts the course written in Ms Word format to the Coedu XML based format. Our digitizer has developed an own written conversion software for sake of quick work. The digitizer is an informatics engineer. Of course, some developers are working with the Course Editor, so the before mentioned conversion is not always necessary.

The cooperation of the before mentioned persons is based on a well defined division of tasks. The curriculum is compiled by the developer together with the lesson closing and the module closing tests. The instructor responsible for the subject revises the curriculum. The compilation of the exam tests on the basis of the detailed requirement system is the task of the instructor responsible for the subject, because this is the competence of the given professional department.

VIII. ON-LINE EXAMINATIONS

Students have to take exams under strict control. For security reasons it is possible to take an examination only on dedicated computers of the selected computer rooms of the university. Students are solving the exam tests presented by computers. In the case of automatic scoring students can view their score at the end of the exam. If the test is scorable by the tutor, then the results are known within three days.

The test server is a dedicated server; it does not serve other purposes. The online instruction is made by an other server. Of course there is a server for back-up purposes, too.

Tutors can reach the test server only with a secure method. They are using the Cisco VPN client to see the tests of the students. Test scores are converted to grades in a predefined manner. Tutors have to write the grades to the united study computer system named Neptun. Students can query their grades from the computer system using an Internet connection.

In the case of a power or computer network failure students can fill the prepared paper based versions of the exam test. In such cases the tutor manually has to score the answers. These power or computer network failures are generally rare.

IX. THE PREPARATION OF STUDENTS FOR STUDIES

The special circumstances of e-learning based distance education necessitate the preparation of students for the use of the new tools. In the first semester they have a special subject named Proseminarium. This subject introduces them to learning methods, and instructs them to use the possibilities of the Coedu system. They have practical tasks to solve: they have to fill the module closing tests of the course, have to send e-mails to the tutor, and have to send messages to the chat Forum.

X. QUALITY MANAGEMENT

To improve the quality of instruction we use three methods.

- The system administrator regularly (once time a month) prepares a digest of the most interesting student remarks from the chat Forum. Students are very critical, when they are writing experiences about the training process to each other. These digests are sent regularly to the leaders of the university.
- The tutors are collecting the remarks of students sent by e-mails. These remarks are discussed on the conferences of tutors in each semester.
- Once a year, the leader tutor collects the opinion of students in the form of an anonymous online questionnaire. The data are analyzed and sent to the leaders of the university.

Of course, we used to talk with students on the occasion of signing in, at the beginning of each semester. The leader of Adult Training Center regularly holds open hours, and collects the observations of students.

The data of student satisfaction are the base of ordinations of the leaders of the university to improve the quality of instruction.

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The Web Enhanced General Physics Course

Gene G. Kuleshov
Department of Computer Science
Touro College
27 West 23rd Street
New York, NY 10010 USA
(genek@touro.edu)

Abstract

The presentation describes the set of ready to use simulation software that can be utilized for both the lesson illustrations and the virtual lab assignments. The interactive simulations allow learners to explore a topic by comparing and contrasting different scenarios. Users may get a deeper exposure to the subject matter either by modifying parts of existing simulation or by building a new simulation from scratch. Another advantage for the users is the ability of simulation illustration to be paused and restarted for reflection and note taking. Each chapter of the course is followed by originally developed computerized test. The computerized tests are three levels hierarchical applications that allow the random access to the question data bank.

Categories and Subject Descriptors

K.3.2 [Computers and Education] Computers and Science Education.

General Terms

Curriculum, Virtual Labs, Simulation

Keywords

Learning Styles, Interactive Tutorials, Computerized Tests, Distance Education

Introduction

Thousands of educators from across the globe are involved into activities to explore the opportunities and innovations of education in XXI century. One of the most popular tendencies in contemporary education is development of either Internet

based (online) or Internet enhanced or just computerized courses.

The General Physics course offered at Touro College has been totally redesigned to allow prospective physics instructors to teach with technology. The course has been transformed from a traditional style to the one in which technology is the focus of the curriculum. The Blackboard-6 environment of Internet is being used to gain access to a wide range of resources: the lesson notes, the animated illustrations, the virtual lab, the web link tutorials, and the original computerized tests.

The presentation describes the set of ready to use simulation software that can be utilized for both the lesson illustrations and the virtual lab assignments. The interactive simulations allow students to explore a topic by comparing and contrasting different scenarios. Users may get a deeper exposure to the subject matter either by modifying parts of existing simulation or by building a new simulation from scratch. Another advantage for the users is the ability of simulation illustration to be paused and restarted for reflection and note taking.

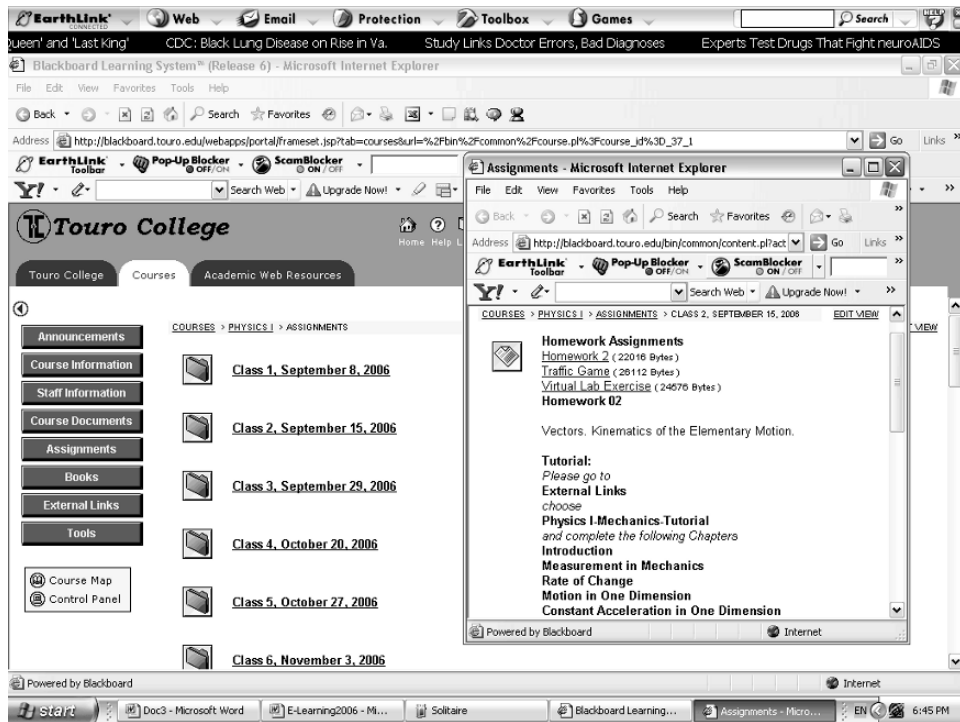
Each chapter of the course is followed by originally developed computerized test. The computerized tests are three levels hierarchical applications that provide the random access to the question data bank.

Computerized Course Curriculum

Course assignments scheduled weekly (see the illustration below) represent the components of student's activities; they are notes, Internet tutorials, virtual labs, and homework. Two last ones might be submitted either as hard or as soft copy (text file) stored within Digital Drop Box. Another extensively used option of Blackboard environment is the Discussion Board where each student might participate in discussions which are moderated by professor [1 - 4].

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The views expressed are those of the author and do not reflect the official policy or position of the Touro College and Touro University International.

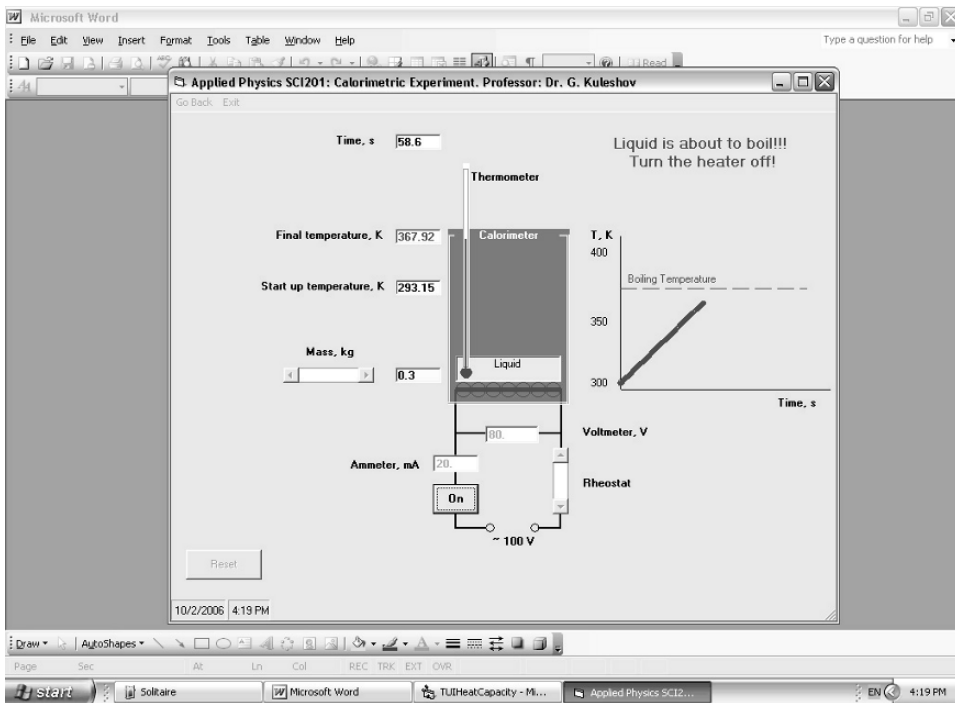
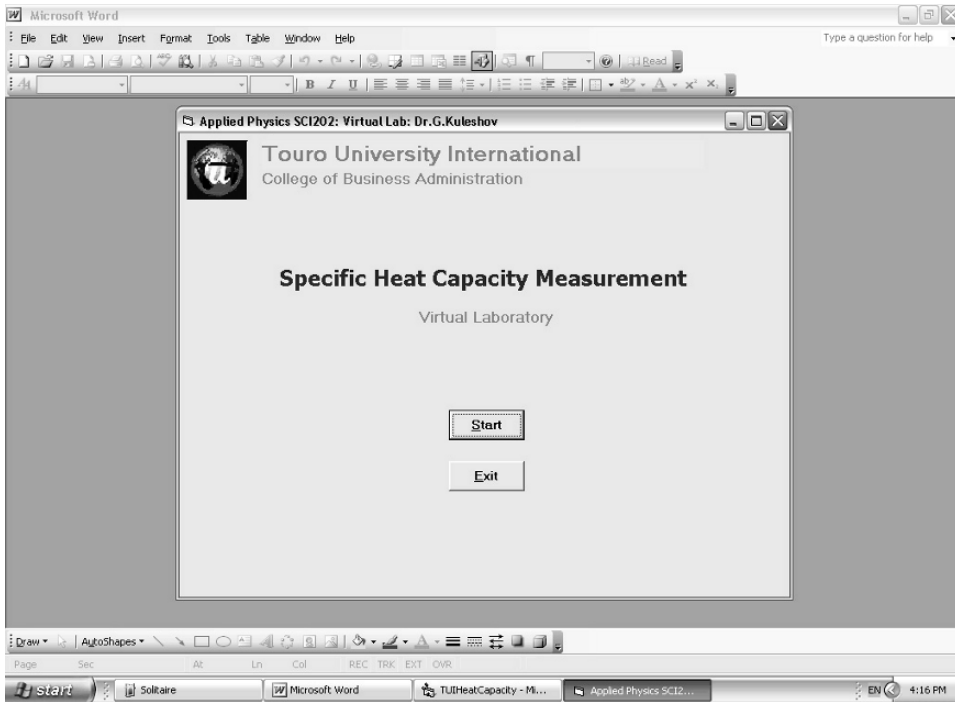


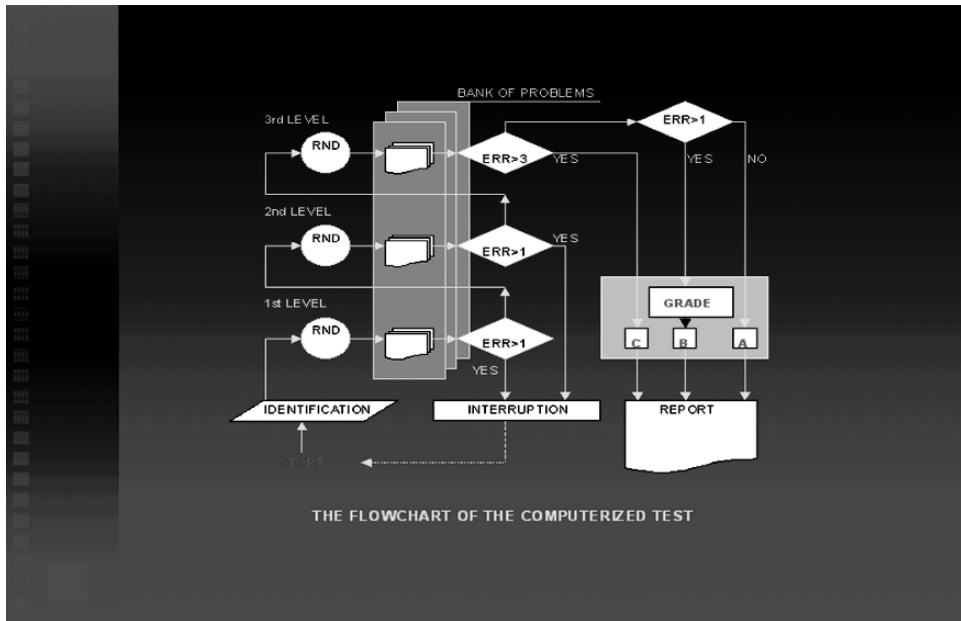
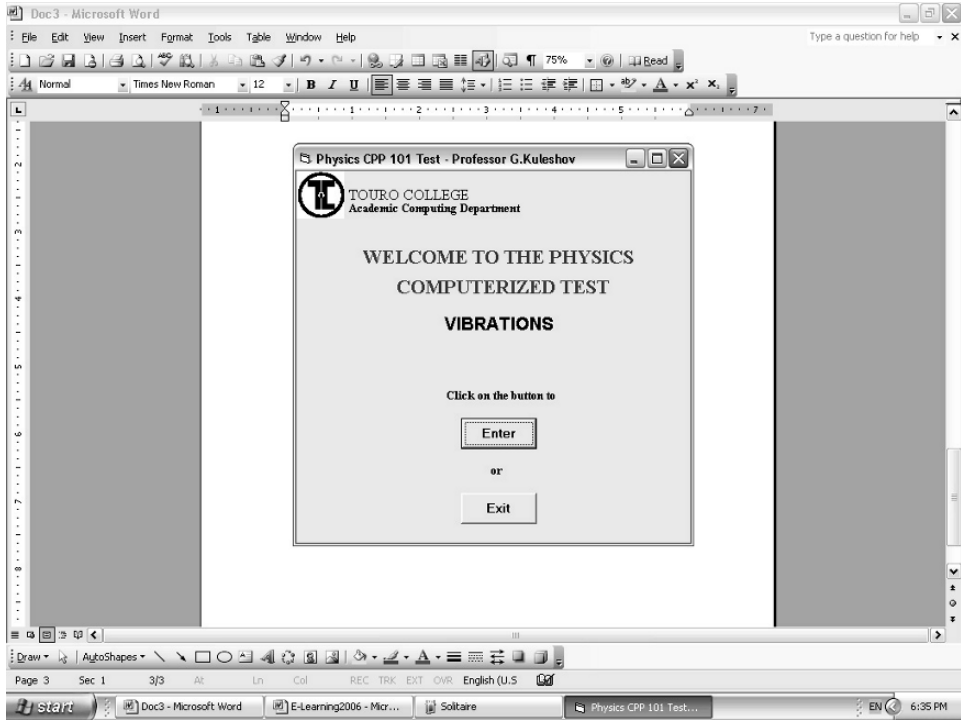
Original Virtual Lab Assignments/Interfaces

With the availability of modern programming and prototyping tools, many useful simulations and web-based applications have been added to the regular teaching techniques [5]. There is a lot of Physics simulation freeware available at Internet; however, some chapters of the course are not supplied with appropriate simulation software. A few of them have been originally developed to cover chapters Mechanics, Heat and Thermodynamics, Vibrations, Electricity and Magnetism, and Optics. These new virtual labs components are interactive interfaces and assignments which in turn include brief description of the physics phenomena being discussed and the experimental device utilizing the specific method of measurement. Both the interactive dialogues with user and data visualization of physical experiments allow students to modify the experimental conditions and to explore the physical science in depth.

Interactive Computerized Tests

The Computerized Test [6] is the Visual Basic application developed to check the student's ability to solve problems related to each covered chapter. The test has a hierarchical structure that includes problems of three levels of difficulty. On the first level, students are supposed to know just definitions. They need to answer correctly either three randomized questions in succession or at least four questions of five to get access to the next – advanced level. In the case of two incorrect answers provided on this introductory level, the student will find himself out of the test. When the student reaches the second level, he or she will need to solve again either three randomized problems in succession or at least four of them to get access to the highest level of the test. There is a special Report form that includes student's name and ID as well as all the results on each level and the test final grade. The flowchart of the Computerized Test is shown below.





Conclusions and Future Work

The use of web enhanced curriculum to teach and reinforce Physics concepts based on specific learning objectives has been a positive experience for both the faculty and the students. The advantages of teaching with technology are the ability of students to get access to the course materials at any time and at any place and the opportunity to strengthen students' technology and computer skills. Learning about simulations is also important since simulations are frequently employed to make predictions or test ideas by scientists and technologists. Development of interactive simulation software is currently being considered for several other Science and Mathematics courses, and will be implemented, conducted, and assessed to evaluate their effectiveness.

Access to the Course

To get access to the course, open Touro College website (www.touro.edu) then select **Web Courses** and **Blackboard** from pop-up menu. Login with User Name **Guest** (case sensitive) and use the same string as a Password. Click on the link **Physics I (Physics II)** and you are welcome!

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Accessibility and Model-Based Web Application Development for eLearning Environments

Sabina Jeschke and Helmut Vieritz

Berlin University of Technology

Department of Mathematics and Natural Sciences

Straße des 17. Juni 136

D-10623 Berlin, Germany

Abstract- eLearning and eScience technologies offer a particularly wide range of possibilities for pedagogical concepts supporting the special needs and interests of the individual user. The two decisive advantages are defined by interaction capability and the ability to adapt the presentation to the user, both practically unachievable using traditional media. These two features are the key to extend the methodology of teaching scenarios as well as the support of individual learning strategies. Thus, the integration of new media into the academic education possesses the potential to assist in transcending the disadvantages facing disabled people in education. Based on semantic content encoding and model-based development, a broad range of accessibility features can be supported.

I. INTRODUCTION

Learning and eScience platforms are characterized by non-linear information structures and intensive use of graphical and interactive components. These, together with the dynamic generation of content, are the properties, which support new presentation approaches and new forms of learning environments. Unfortunately, the resulting Web applications are often not accessible for disabled persons. In contrast, computer-based technology allows a complete separation between content and presentation. Therefore, new media possess the potential to adapt the presentation to individual users, at least in principle. To build accessible Web applications, one has to consider the specific needs from the beginning of the design process. Based on recent proposals for a model-based Web application development, we discuss the essential modeling requirements to ensure enhanced accessibility in eLearning environments.

A number of guidelines (designed and published by the World Wide Web Consortium (W3C), the European Commission, national governments and others) have been passed during the last years to address the issue of accessibility. The majority of the suggested rules focus on easy access to (more or less static, less interactive) information portals. Often, the paradigm of a universal design for all people is assumed. However, the existing concepts do not address the implementation of highly multimedia-based interactive learning and teaching contents for disabled persons, nor are they well-suited to this task.

Advanced eLearning platforms are capable of adapting the presentation to the user and can provide him with additional information about multimedia content, navigation and presentation suited to his own needs. Therefore, the universal design approach can be replaced by a user-centered or target-group-specific design which is based on two main paradigms:

Semantic encoding: The flexibility of the separation of content and representation requires extensive semantic encoding of all content: supporting the underlying semantic technology is vital to the realization of a broad accessibility of highly interactive virtual knowledge spaces and incorporating intelligent tools for the development and administration of content. Here, it is important to mention that semantic encoding may not be restricted to the content elements themselves, but has to be extended to all aspects which are highly content-related as, for example, navigation mechanisms. Semantic encoding means explicitly storing all relevant knowledge concerning the Web application to provide the technology of the user with the needed knowledge to present the content in an appropriate way. Thus the encoding is presentation-oriented.

Model-based development: Model-driven development refers to a design process where all information is available to provide the designed application with the semantic information about the used objects, their relations and meanings. Storing this knowledge in a way enabling the compiler to generate automatically all required information, model driven design processes for Web applications are a promising approach to satisfy both the requirements of learning environments and accessibility. The conceptual design makes it possible to enable accessibility without extra effort.

More precisely, nowadays some approaches examine the possibilities of Web application development based on Model-Driven Architecture (MDA). Web applications are at first designed in a precise Conceptual Schema (CS) described with the Unified Modeling Language (UML) which afterwards can be translated by a model compiler into the corresponding application. The design of a CS is, applied to Web applications, an even bigger challenge additionally complicated by some missing features of UML

when applied to modeling Web-based applications. Not only is it necessary to map the structure and behavior of the whole application but also that of the intended navigation and presentation. Prototypes of model compilers are already in existence.

Within the BeLearning-Project* at the Berlin University of Technology, model-based development is investigated. Moodle [1] (as a non field specific eLearning platform) and Mumie [2] (as a field specific platform for mathematics) serve as demonstration environments to evaluate the potential of model-driven development concerning accessibility of eLearning platforms.

Finally, in comparison with traditional teaching materials and media forms, the modern information and communication technologies offer new approaches concerning far-ranging user adaptivity concepts through flexible content adaptation to individual needs on all levels.

II. ACCESSIBILITY

Different kinds of Web applications demand different paradigms to assure accessibility. The universal design is convenient for static content whereas eLearning platforms with dynamic content generation require other paradigms for an accessible design.

A. Universal Design

The recommendations of the W3C are based on the universal design paradigm. In general the Web presentation has to present all information readable for all users. That means a textual pendant must be available for all multimedia content like pictures, graphics, animations etc. Even the input must be independent from the input device. The Web Accessibility Initiative (WAI) formulates four principles of accessibility in the working draft of the to-be recommendation [3]:

- Content must be perceivable to each user.
- User interface components in the content must be operable by each user.
- Content and controls must be understandable to each user.
- Content must be robust enough to work with current and future technologies.

The fields where accessibility is relevant can be split-up along the lines of two main issues: perception and interaction (see Fig. 1).

So far the existing standards do not state sufficient recommendations for knowledge, learning or expert portals. They are not particularly applicable to these areas as they barely integrate the characteristics of the new media like multimediality and interactivity. These, however, are the properties, which lead to new presentation approaches, to new forms of teaching and learning and which are essential in the development of new learning environments.

* We would like to thank the European Social Fund ESF for funding the BeLearning-project.

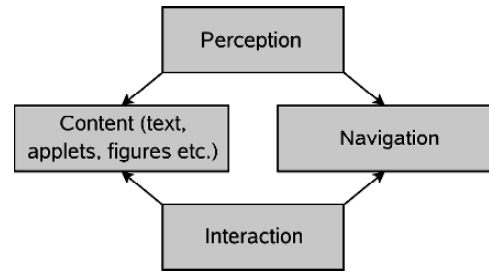


Fig. 1. Content and Navigation

B. Target-Group-Specific Design

Dynamic Web applications allow adaptation of the presentation to the needs of the users as well as providing additional information about multimedia content, navigation and presentation. The first paradigm based on this is a target-group-specific design which classifies the users in different groups with specific characteristics. For physically disabled people a useful classification would start with functionality and not from medical diagnosis such as visually, hearing, physical and mental impaired people.

The flexibility of the separation of content and representation requires, however, extensive semantic encoding of the complete content: supporting the underlying semantic technologies is vital to the realization of a broad accessibility of highly interactive virtual knowledge spaces and incorporating intelligent tools for the development and administration of content. Here, it is important to mention that semantic encoding may not be restricted to the content elements themselves, but has to be extended to all aspects which are highly content-related as, for example, navigation mechanisms [4]. Semantic encoding means explicitly storing all relevant knowledge concerning the Web application to provide the technology of the user with the needed knowledge to present the content in a proper way. Thus the encoding is presentation-oriented. Even the storing of data in a XML-dialect has to respect some issues to support accessibility:

- authors have to be able to explicitly associate multiple media objects with alternatives
- semantic-rich XML-language
- documentation and export of the semantic information

But in general it is not possible to classify disabled persons in some groups and therefore this paradigm is only an intermediate step.

Even a classification of mental models addresses the issue of adaptation in the fields of learning and teaching in a better way. For example the mental models of blind people depend on if they are blind by birth or lost their eyesight at a later stage of their lives. The association of colors and geometrical notions is as different as between blind and not visually impaired people. The impact of mental models for accessibility is part of further examination.

C. User-Centered Design

When considering disabled people one has to realize that almost each has his own specific limitations. User-centered

means addressing the individual needs of each user, both automatically and by explicit request to the system. There is no separation of groups. The user can choose if he wants to see pictures or not and so on. This is the most flexible but difficult paradigm since the pre-estimation of users' requirements poses complex questions. Here the transition to usability is seamless.

The changeover from a universal to a user-centered design cannot be made in one step. The following course of action is useful:

- First types of presentation that are accessible for all users are integrated. That means text, navigation, links etc.
- Second, types which can be transformed equivalently to other presentation modes. In principle these transformations are a purely technical challenge.
- Finally, types without a possible equivalent transformation to other modes of presentation require new pedagogical and higher level approaches as well as further research. In the beginning these presentation forms cannot be used for essential information but for additional support.

In general the user-centered design is more capable than the universal design to fulfill the requirements of the intensive use of multimedia and interactivity in eLearning environments. As an intermediate step the target-group-specific design can reduce complexity.

D. Summary: Demands of Accessible Dynamic Web Applications

Dynamic Web applications storing semantic information demand new concepts of application development. In order to store the descriptions of multimedia objects and interactions in a semantic way, a development process is needed which supports "semantic thinking" to generate this information. Thus, it is possible to generate the information without additional effort during the development process. The process of developing the Web application has to be schematic and requires specification tools which are powerful enough to describe complex Web applications and abstract enough to be processed by a compiler. UML and model-based Web application development extending MDA for the Web use offer these features. The additional information which makes the Web application accessible can be derived from an extended CS. This approach is presented in the next chapter.

III. CONCEPTUAL MODELING

Several recent projects examine the possibilities of conceptual modeling to develop Web applications. The MDA-methodology has been extended to accomplish these needs. Existing approaches commonly use UML and some extensions to develop a CS which describes not only structure and behavior of the Web application but navigation and presentation as well. Some examples are:

- Object-Oriented Web Solutions (OOWS) [5]
- Object-Oriented Hypermedia Design Method (OOHDM) [6]

- WebSite Design Method (WSDM) [7]
- Web Markup Language (WebML) [8]

Among the approaches for model-driven Web application development examination of accessibility is still unusual. Currently some additional problems include: The modeling of dynamic Web applications since current approaches are often intended for more or less static informatory Web applications. The integration of later modifications of the model has to be possible and the compiler process should enable the reverse direction of the process as well. Models are necessary to describe flexible interactions with the user.

Here two projects are presented. They are focused on the enhancement of navigation models to support accessibility and on adaptive linking. First, based on WSDM the Dante-project [9] aims to support technologies like screen readers with additional information about the navigation. Second, the OOWS-approach includes the description of adaptive navigation techniques in the early process of Web modeling [10]. These approaches affect, first and foremost, accessibility for visually impaired users.

A. WSDM and Dante – Additional Information about Navigation

The WSDM is a user-centered Web page design method. Web pages can be developed in a systematic way and different phases of the generation are specified. WSDM is focused on the presentation of information thus interaction beyond linking is not supported.

It includes the following parts (see Fig. 2). Starting from a clarified mission statement which describes the intended purpose and subject of the Web application, possible users are identified and separated into different audience classes in a hierarchical scheme. The characteristics of each class are specified. During the conceptual design phase the task and information modeling and the navigational design are elaborated. Finally the implementation design and the Web application will be developed.

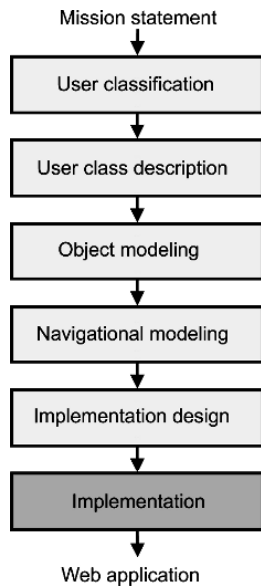


Fig. 2. The WSDM-Process

WSDM uses an OWL-ontology (Web Ontology Language) to describe the modeling concepts. As a user-centered approach it is suitable to involve the needs of disabled people. In contrast, the approach is focused on the presentation of information and less on interactivity. Further examination is required to see if it can be extended to include user interfaces and similar models.

The Dante-project is based on WSDM and aims to improve the access of visually impaired people to Hypermedia environments – especially the Web. It is focused on devising a tool to analyze and transform Web pages using a model-driven approach and generating annotations from the design specifications.

Usually, visually impaired users have to rely on screen readers. In some countries Braille-devices are commonly used, having the same impact on this discussion. These assisting technologies read the content sequentially and cannot detect and present the meaning of different page objects. Without further information this implicit knowledge of the structure is not accessible to visually impaired people. Providing the screen reader with extra semantical knowledge can avoid this problem. Thus, the Dante-approach allows semantical annotation of Web pages to support assistive technology with explicit knowledge of the structure of the Web contents. The identified objects are annotated with terms of the Web Authoring for Accessibility ontology (WafA). Currently, such annotations were done manually and do not address the problem of dynamic content.

In combination with the Web design method WSDM it is possible to fully automate the generation of semantical annotations used for Dante. It is estimated that 85 % of the annotations can be provided in this way. This makes Dante

interesting for dynamically generated content. The Dante-project is in effect based on the universal design paradigm since annotation is created without user-specific demand.

B. OOWS – Adaptive Linking

OOWS extends the object-oriented software development approach OO-Method [11] with additional capabilities to capture the navigational and presentational requirements of Web applications. Since it extends an object-oriented design approach it seems to be more suitable for the conceptual design of complex server-based Web applications.

The OO-Method was extended with three additional models: user, navigation and presentation model. OOWS defines a set of activities to properly specify the functional, presentational and navigational aspects (see Fig. 3). A fully operative Web model compiler which includes the presentational layer is part of future work.

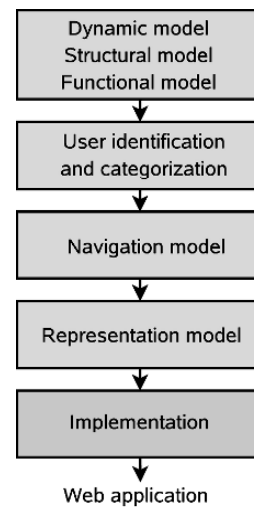


Fig. 3. The OOWS-Process

An approach is combined with the navigational model to include the description of adaptive navigation techniques in the early process of Web modeling [10]. Even if this technique is not intended to improve accessibility it can be extended to support orientation for visually impaired users since they use links to gain a quick outline of a Web page. Three techniques of linking are included: link-annotation, link-hiding and link-ordering. Since this approach is not focused on accessibility there is no underlying design paradigm.

C. The Approach of the BeLearning-Project

The BeLearning-project aims to enable handicapped people to profit equally from modern information technologies. It includes conception and prototypical development of accessible highly interactive eLearning and eResearch

environments. Additionally it is focused on the area of mathematics, natural sciences and engineering.

As discussed the field of navigation is one of the major issues to support accessibility. Another one is multimedia content like images and animations. Starting from both approaches presented above to improve navigation techniques, the BeLearning-project examines the possibilities to improve accessibility to multimedia content. This affects particularly visually impaired users.

Images, graphics etc. have different functions in Web content. They can be links, illustrations, examples etc. Following functions are possible:

- Decoration: The image carries no additional information.
- Representation: The image accompanies the text and amplifies information.
- Organization: The image clarifies the structure of the text.
- Interpretation: The image explicates complicated parts of the text.
- Transformation: The image converts the information of text to support memorizing of information, to tie different parts of the text into a whole etc.

Current discussions concerning presentation are usually focused on the meaning to be conveyed by the objects as the description of a visual object is meaningless to visual impaired people if it is not related to concepts available to their imagination. In addition it is important to communicate the significance of the picture so that the user can understand why the image is there and if it is necessary to recognize all details. In fact that does affect only a portion of all pictures. A lot of these aspects can be carried by text too or are not necessary to understand the content. Nevertheless a complete substitution is not possible.

If the Web application model declares the function of an image, applications can decide which substitution could or need to be applied. Also, function and intention of an image must be clear for the user to make this kind of content accessible. This sort of "semantic information" is available from the Web model too and can be processed by the model compiler. It is planned to embed this processing of multimedia content into a target-group-specific design where the user model includes specific demands of visually impaired people too.

According to the discussed issues an approach (see Fig. 4) is planned which explicitly addresses the above-mentioned main fields of accessibility - perception and interaction - and to meet the demands of complex server-based Web applications like eLearning environments. Therefore it is necessary to design representation and interfaces too. In the representation model images are combined with objects from earlier models like the functional model and the navigational model which declares the function represented by the image. In most of the cases alternatives are possible.

The development of the user model and the conceptual design of the application as well as interface design and navigation design are parallel operations affecting each other. Additionally, the distinction between navigational

links and other actions will become less and less pronounced in the near future as currently demonstrated by the AJAX-technology (Asynchronous JavaScript And XML).

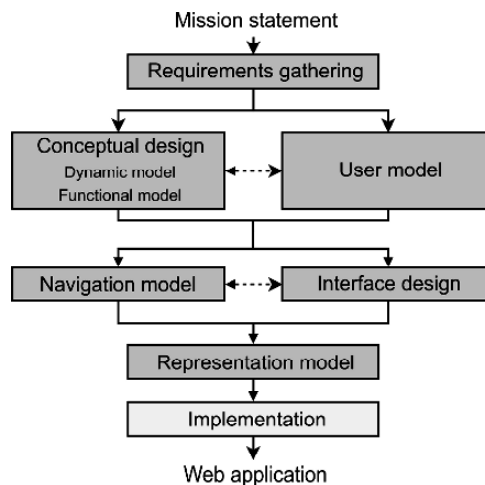


Fig. 4. Concept of the BeLearning-Development Process

IV. CONCLUSIONS

With all presented approaches combined, model-driven Web development can support accessibility in the fields of navigation and illustration. This is not a general approach to support accessibility in all aspects since the support of interaction is not discussed and also multimedia includes not only images. However the basic idea is applicable to other fields too: Accessibility at first is not a question of a simple replacement with other media but to extract the function and purpose of information and find ways to describe these information with models which are processible by compilers. Even if interactions with the user are not discussed in detail here, they are affected by the issues of perception too. Often the problems of interaction are at first not problems of input but orientation, explanation etc.

The following topics are subject to further examination within the BeLearning-project:

- the concept of mental models for use with user classification to support accessibility
- the model-based development of dynamic Web applications
- the integration of interactions in the model-based Web application development process.

Further possible issues for future work include other kinds of multimedia content like applets, the use of SVG (Scalar Vector Graphics) to enhance accessibility etc.

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Creation of a teaching timetable using random variables – The STB application

C. T. Panagiotakopoulos
University of Patras
Archemedes str., Building 7, 26504 Rio
Patras, Greece

A. D. Kameas
Hellenic Open University
23 Sachtouri, 26222
Patras, Greece

Abstract - The creation of a teaching timetable based on the needs of students and teachers is a problem hard to solve. In this paper we introduce the basic operation parameters of the STB application with emphasis to the processing module. The application, as can be deduced from the results of testing in cases having varying degree of complexity, can create the teaching timetable of a typical high school based on all the relevant limitations and constraints that result from our educational system. The processing module operates with random variables and it gives satisfactory results within reasonable processing time.

I. INTRODUCTION

In recent years, several attempts have been made for the solution of the problem of creating a teaching timetable using many and different methods. Among them are:

- linear programming [1],
- simulated annealing [2],
- constraint logic programming [3]; [4],
- graph colouring heuristics [5],
- using heuristic and meta-heuristic algorithms [6]; [7], and
- evolutionary, memetic and genetic algorithms [8]; [9]; [10]; [11]; [12]; [13]; [14].

In this study we introduce the application STB (School Timetable Builder), which used random variables to manage a set of teachers to each of whom is allocated a number of teaching hours and each having a set of constraints. With continuous random tests (sampling with or without relocation) and potential acceptance or rejection of every trial the teaching timetable of a school with seven teaching hours daily can be created, using STB application, as it described in the following sections. The aim of this paper is only to introduce the working concepts of the STB application; performance data will be published in the near future.

II. BASIC FEATURES OF THE APPLICATION

STB application has been developed in object based the

high-level programming language Microsoft Visual Basic 6.0. It includes, apart from the initial conditions generation module, four more modules: (a) Database, (b) Basic timetable processing, (c) Timetable optimization, (d) Timetable output. These four independent modules that constitute the application are connected between them and also with the basic selection menu. Moving from one module to another is easy and fast, with the fewer possible moves.

The Database module is designed and constructed exclusively using the programming language. The Database stores data regarding teachers, the classes that are assigned to them (working hours), the interdependences of their working hours, and also the constraints for each one. It is possible to check the recorded data, so as to discover conflicting constraints and to estimate the possibility of creating an acceptable timetable. The constraints imported are the usual that apply in a school, such as: preferences for teaching hours, hourly or daily detachments, teacher's obligation for teaching in other classes, division of classes and co-teaching (interdependence of many teachers with many common or partly common classes).

The Processing module uses random variables for the creation of the timetable version based on the specific (imported from the database) constraints. Every time that the application is running a different timetable version is created.

The Optimization module attempts the improvement of the timetable version created in the previous stage, with respect to the teachers' preferences.

Finally, the Output module gives the opportunity to the user to visualize the timetable version in the computer screen as a whole, or for each teacher, and also to print the timetable using the appropriate formatting.

In this paper, the elements concerning the STB Processing module will be analyzed, which from the developers view, are much more important than the others.

STB application uses random variables. For the creation of random (more accurately, pseudo-random) numbers, the function RND was used, which in Visual Basic 6.0, according to Microsoft, starting from command RANDOMIZE can

return pseudo-random numbers of single precision uniformly distributed in the [0,1] range with the linear-congruential type:

$$X_1 = (X_0 * A + C) \text{ MOD } (2^{24})$$

where X_1 =new number, X_0 =previous number and A, C are constants [15].

Figure 1 shows a screen shot of an instance of STB while executing.

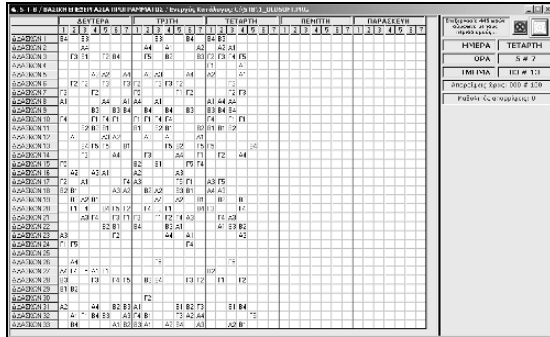


Fig. 1. Screen shot of an STB application instance

III. FUNCTIONALITY OF THE PROCESSING MODULE

In figure 3, the flowchart of the STB Processing module is shown. The search of a valid teacher – class combination takes place each time in three hierarchical levels (grayscale area of figure 2). To pass from one level to another a different counter is used. The values of the counters thresholds can be controlled by the user (figure 2).



Fig. 2. Screenshot of the window where the user can adjust the values of the escape counters

Level 1: Involves random teacher search and random class search within the teacher’s working hours. The acceptance and tabularization of a teacher – class combination will happen only when there are no conflicts (a) with previous tabularizations and (b) with constraints that concern the teacher and the class selected. The first level is exited when the value of a counter LC1 exceeds a user specified threshold (figure 4).

Level 2: Involves random teacher search and sequential class search within the teacher’s working time. Again, acceptance and tabularization of the teacher-class combination will happen only if there are not any conflicts (a) with previous tabularizations and (b) with constraints on the teacher and the randomly selected class. This level is exited when the value of counter LC2 exceeds a specified threshold. (figure 5).

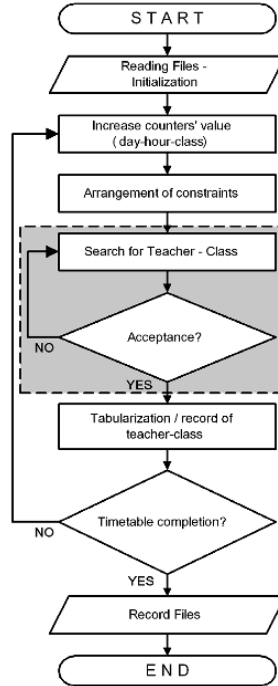


Fig. 3. The basic logic diagram of the STB Processing module

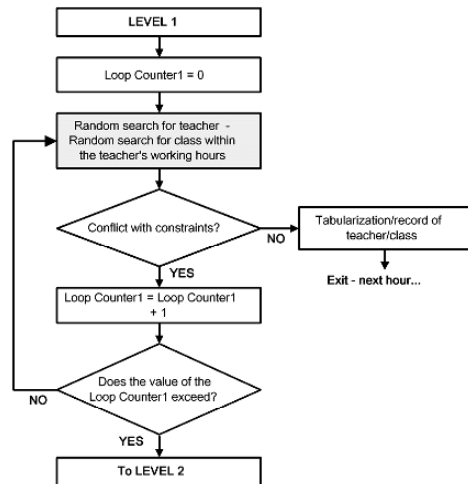


Fig. 4. Logic diagram of processing in level 1

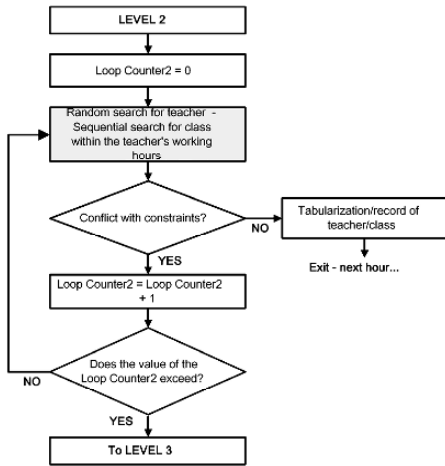


Fig. 5. Logic diagram of processing in level 2

Level 3: Involves random teacher search D and sequential class search T within the teacher's working hours. In this level, it is almost certain that the class T selected will be impossible to accept, as it would most certainly be allocated to another teacher A. Then the application attempts a set of mutual exchanges, so as the class T to be allocated to the teacher D, while it is attempted to re-allocate class T to teacher A in a previous hour of the same day or in previous days. The acceptance and tabularization of teacher D – class T combination as well as of teacher A – class T new combination, will happen only if there are not any conflicts (a) with previous tabularizations and (b) with constraints on both teacher – class combinations. The third level is exited when the value of counter LC3 exceeds a specified threshold (figure 6).

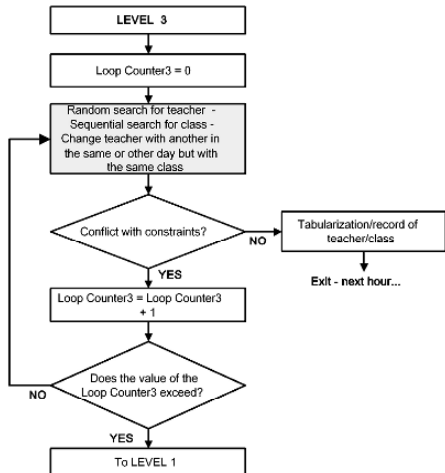


Fig. 6. Logic diagram of processing in level 3

When a “valid” teacher-class combination is found at any of the 3 levels, counters LC1, LC2, LC3 are reset and search begins again from level 1 for a new teacher – class combination. The settlement of commitments at any time of the timetable concerns the assignment of (a) free hours per class and (b) reserved teachers’ hours at specific classes.

Apart from loop counters LC1, LC2, LC3, there is a fourth counter LC4, which functions in addition to the others and enforces – depending on its value – the rejection of current hour. As a result, the three counters are reset, so that the application can start searching from scratch a teacher – class combination for the current hour. Finally, a fifth counter registers the hour rejections per day, so that when the number of these rejections surpasses a set limit, the application rejects the entire timetable and starts its creation anew.

The values of the five counters are adjusted through the application either during the initialization of the Processing module, or even during runtime. At any time, the user can move to the main menu, and the execution of the procedure can be interrupted.

The design of the Processing module described above aims at offering at least one timetable version, very quickly, without solving the problem of teachers’ free hours or the problem with teachers preferences for first or last hours. But using the fact that the user can detach at will teachers into specific hours of one or more days renders the produced timetable version to be “teacher-centric”. Actually, by detaching every teacher for specific hours a day, one can reduce the range of available hours, which the application can combine him with a class; hence, the teacher preferences and free hours are adjusted accordingly. Naturally a great number of detachments will reduce the possible outcomes. So, either the application will not be able to build a valid timetable version or it will need too much time for this.

IV. MEASURING THE FUNCTIONAL PARAMETERS OF THE APPLICATION

The application has been tested with three types of timetables, each having a different degree of complexity due to the increasing number of constraints from the first towards the third. Note that the third type is a real timetable of an ordinary Junior High school in an urban city with all its special characteristics and its diversity, whereas the rest were produced from that one by gradual lifting of constrains.

We requested the application to create 100 versions – completed timetables from every type, registering the completion parameters, as well as the total number of rejections – iterations for each of the 100 completed timetable versions that resulted from making four different adjustments per type in the rejection counter LC5. This counter controls the total rejection of the program (that is, the iterations until its completion).

The performance of the application took place sequentially depending on the timetable and the value of LC5, in four completely identical personal computers having Intel P4 / 2,8GHz, 256MB RAM, HDD WD 80GB / 8MB cache, with Microsoft Windows XP Professional Edition.

The time-dependent storage interrupt, every other application scheduling as well as network connection were disabled. Measurements were taken at one second resolution. The results are shown in Table 1.

TABLE 1
GENERAL CHARACTERISTICS OF THE THREE TIMETABLES (P1, P2, P3)

	P1	P2	P3
teachers	35	35	35
classes	13	13	13
total available hours (weekly)	1225	1225	1225
total working hours (weekly)	455	455	455
total dependent working hours	0	35	35
total reserved hours	0	92	92
total detachment hours	84	84	445

The time related parameters that determine the completion of 100 timetable versions in each of the three types are shown in Table 2.

TABLE 2
TIME RELATED PARAMETERS OF COMPLETION OF 100 VERSIONS FOR EACH OF THE THREE TIMETABLES WITH DIFFERENT VALUES OF COUNTER LC5

	Counter LC5 rejection value	0	100	250	500
P 1	average time completion	282.6**	203.3**	369.9**	646.9**
	minimum time completion	8.0**	8.0**	9.0**	9.0**
	maximum time completion	1469.0**	1057.0**	2192.0**	3859.00**
P 2	average time completion	229.3**	150.1**	346.0**	649.2**
	minimum time completion	8.0**	8.0**	8.0**	8.0**
	maximum time completion	1177.0**	707.0**	2179.0**	3635.0**
P 3	average time completion*	-	6021.7**	7405.1**	11942.0**
	minimum time completion*	-	53.0**	217.0**	143.0**
	maximum time completion*	-	28247.0**	29032.0**	49067.0**

*It was not possible to complete not even once P3 with LC5=0, although the PC had been operating continuously for 24 hrs.

In figure 7 we have depicted using bar charts the mean completion times (in seconds) for each of the three timetables, using the LC5 values 0, 100, 250 and 500.

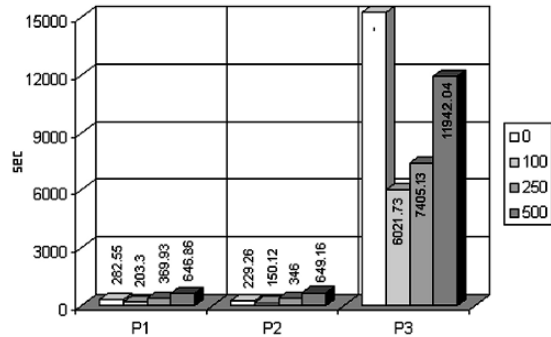


Fig. 7. Mean completion times (in seconds) for each of the three timetables, using the LC5 values 0, 100, 250 and 500

The number of iterations – rejections for the completion of 100 timetable versions for each of the three timetable types is shown in Table 3.

TABLE 3
NUMBER OF ITERATIONS REQUIRED FOR COMPLETION OF 100 VERSIONS FOR EACH OF THE THREE TIMETABLES WITH DIFFERENT VALUES OF COUNTER LC5

	Counter LC5 rejection value	0	100	250	500
P 1	average number of iterations	23,2	5,37	5,03	4,89
	minimum number of iterations	0	0	0	0
	maximum number of iterations	124	30	31	29
P 2	average number of iterations	21,89	4,53	5,45	5,7
	minimum number of iterations	0	0	0	0
	maximum number of iterations	115	23	35	32
P 3	average number of iterations	-	156,4	102,9	108,9
	minimum number of iterations	-	1	3	1
	maximum number of iterations	-	740	386	415

V. CONCLUSIONS

In this paper, we presented and analyzed the basic operational parameters of STB application, with focus on the Processing module. As it was shown from analyzing the results of measuring the application performance with timetables of different degrees of difficulty, STB can build successfully the timetable of an ordinary high school considering all relevant limitations or constraints in our educational system (co-teaching, class division, detachments, teachers allocated to specific classes etc.). STB Processing module uses random variables. With random or even sequential sampling, with or without re-location, a valid teacher – class combination is located; this is accepted by the application if there are no conflicts with constraints on the specific day, hour or class.

Special counters dictate the initialization of the functional

parameters and the reassignment of teachers and the hours allocated to them per day or even totally, if their values overcome particular limits, so that the application can restart building the timetable from the beginning according to the specific constraints. This approach, as has been shown, produces satisfactory results without requiring excessive processing time. The use of random variables allows the continuous creation of timetable versions which offers flexibility and gives the opportunity of choice.

It has been shown that the STB application provides one effective solution to the complex problem of timetabling. Our further research is twofold: (a) we intend to compare STB with other similar applications using a set of benchmark situations and (b) according to the findings, increase the performance of the application regarding the time of timetable completion.

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E-learning and handicap: new trends for accessibility with model driven approach

Amina BOURAOUI
Research Unit of Technologies of
Information and Communication
UTIC
Ecole Supérieure des Sciences
et Techniques de Tunis,
5, Av. Taha Hussein, B.P. 56,
Bab Mnara 1008, Tunis, TUNISIA
Hannibal.a@wanadoo.tn

Mohamed JEMNI
Research Unit of Technologies of
Information and Communication
UTIC
Ecole Supérieure des Sciences
et Techniques de Tunis,
5, Av. Taha Hussein, B.P. 56,
Bab Mnara 1008, Tunis, TUNISIA
Mohamed.Jemni@fst.rnu.tn

Mohsen LAABIDI
Research Unit of Technologies of
Information and Communication
UTIC
Ecole Supérieure des Sciences
et Techniques de Tunis,
5, Av. Taha Hussein, B.P. 56,
Bab Mnara 1008, Tunis, TUNISIA
Mohsen.laabidi@esti.rnu.tn

Abstract-This paper exposes an approach to create accessible contents for e-learning objectives dedicated to handicapped persons. This preliminary study focuses on the proposition of a generic abstract meta-model that can be used to define specific models for different platforms and user configurations.

I. INTRODUCTION

Nowadays, e-learning benefits from the fastest growing of Technologies of Information and Communication to empower education and create very sophisticated environments. However, little attention has been devoted to making these technologies accessible to people with various disabilities. In this context, we are working to create a barrier-free learning environment for students with disabilities.

Our project consists in studying the field of accessible e-learning in order to give handicapped users the opportunity to access education using Internet and new technologies just like any other students. This work is based on the OMG's Model Driven Approach [1].

II. STATE OF THE ART

A. Accessibility

The scientific community has recently been aware about the importance of accessibility of disabled people to information technologies, called numeric accessibility.

This word is specifically used to describe tools and means allowing users regardless of their culture, language, age, disability to reach information and new technologies like Internet, without dependence or aid.

In this context it would be desirable that a handicapped person reaches e-learning in the same way and in the same conditions that another person.

The W3C Web Accessibility Initiative (WAI) has been established to raise awareness of universal access. WAI develops guidelines which can help to ensure that Web pages are widely accessible.

The WAI gives a set of recommendations including: the *Web Content Authoring Guidelines* WCAG [2], the *Authoring Tool Accessibility Guidelines* ATAG [3] and the *User Agent Accessibility Guidelines* [4]. The WCAG is intended for web authors, while the ATAG and UAAG are intended for software development communities.

Furthermore, since Internet is the first vehicle of e-learning resources, we can consider that the WAI guidelines may be applied to e-learning objectives. The recommendations are valuable but their main problem is that they are aimed to be universal while learners are different and have specific needs. In addition, they are sometimes complex to apply. The challenge for researchers and developers is to develop tools that help the application of the WAI guidelines in the e-learning field.

B. Assistive technology

Assistive technology is any mean: hardware or software, used to increase, improve or maintain capabilities of disabled persons. It makes handicapped people able to execute tasks that are sometimes difficult or impossible to do without technical aid, and helps them achieve their scholar, professional and social integration.

Assistive technology includes many categories. We are mainly interested by assistive technology aimed to facilitate the use of a computer by a handicapped person. This technology can be composed by conception, methodologies, input/output devices, and specific or adapted software that facilitate access to a computer.

The present tendency in conception methods is to achieve what is called universal access through the application of "design for all" or "universal design". The universal conception encourages the computer system development that is flexible enough to meet needs of the larger range of computers users, independently of age or handicap.

Input devices like Braille terminals and sensory keyboards are used by visually impaired users; alternative pointing systems used by motor disabled people (based on pressure, breath, eye movement, etc); adapted keyboards, tactile screens, etc.

Speech synthesis, speech recognition, screen enlargers, accessibility features offered by constructors such as the accessibility program of Microsoft.

C. E-Learning

Content Management System (CMS) platforms have become popular among web site hosts. Following this trend, Learning Management System (LMS) are being more and more used to construct distant learning environments. CMS is a system used to organize and facilitate content creation. LMS is software system designed to facilitate tasks as well as student participation in e-learning courses.

In the field of e-learning for handicapped learner, these two fundamentals systems are insufficient. To ensure the access of this category of learner to e-learning contents, we propose to add a third system called Content Accessibility System (CAS). The CAS will ensure the adaptation of contents to handicapped context.

III. THE PROPOSED MODEL DRIVEN FRAMEWORK

Model Driver Architecture (MDA) is an approach for application specification and interoperability which is based on the separation of concerns between domain knowledge and platform specificities. It relies on the use of MOF (Meta Object Facility) meta-models and UML (Unified Modelling Language) models for every step of the application life cycle.

This approach depends on the definition of:

- a specification model called Computational Independent Model or CIM,
- a conception model called Platform Independent Model or PIM,
- an implementation model called Platform Specific Model or PSM,
- a set of model transformations (also called mappings).

A. The MDA architecture

1) The CIM

The Computation Independent Model is the business model that describes the requirements of the application. UML use cases may be used at this level.

Added to basics actors in classical e-learning systems, we propose a new actor called *Assistant*. These one will ensure automatic adaptation of handicapped learner access to subscription, contents and results

2) The PIM

The Platform Independent Model is the domain concept model. It's a model that describes all knowledge related to application domain. The application components are specified without considering implementation techniques, but providing generic computing architecture. The PIM is generated from the CIM. The OMG encourages the use of UML at this level.

3) The PSM

The Platform Specific Model is the data and processing model. It describes how a PIM is adapted to an existing platform, by integrating the implementation technical details, and provides the description of a deployable software system. Starting from a PIM, we can obtain one or more PSM's for different chosen platforms. A PSM is in part generated from a PIM. At this level it is possible to use the UML profiles to construct specific cartridges for disabled learner.

4) Model transformations

Model transformations are the heart of MDA, because they are the means allowing gaining in productivity. Transformation rules ensure the passage from one model to another. The mappings can be considered as applications and are described by models.

The OMG encourages the use of the standard QVT (Query, View, and Transformation) which defines the meta-model for model mappings.

5) The proposed Model

The principal idea of this work is to propose a generic framework that describes all the issues involved in creating accessible e-learning content. The generic framework defines high-level requirements in a PIM, which may be instantiated once or more to respond to different accessibility objectives (Fig. 1). The following points describe some of the multiple features that have to be considered.

The user factors The design of applications must be user-centred. In accessible e-learning field, we are in presence of different aspects of user, for example the tutor, the author, the handicapped student and the classical student.

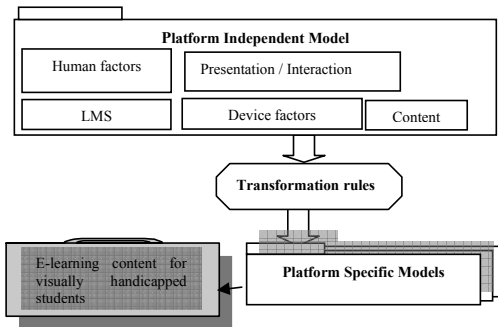


Figure 1. An instance of the MDA accessible e-learning framework

The physical features This part of the model describes all categories of assistive input/output devices that may be used by handicapped persons to access the web based content.

The interaction / presentation features This part integrates knowledge about all possible forms of presentation and interaction with information for different handicaps disabilities (fig. 2). This model will have to integrate different modalities depending on the use of specific or standard devices. For example, in the case of visual impairment, the speech modality is an output format.

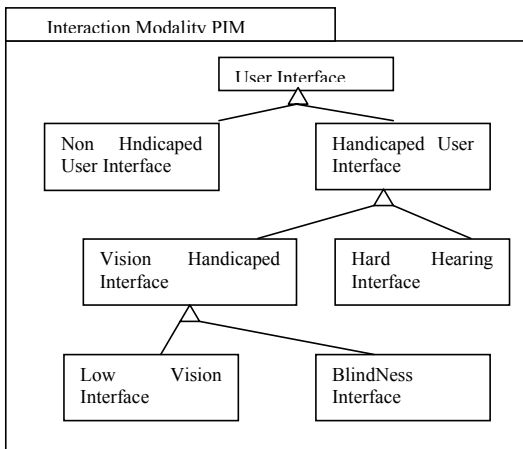


Figure 2. Modality Interaction PIM

The pedagogic content features The content is described in a model specifying its structure. For example, a course may be considered as a set of interrelated learning objects. A learning object can be a module, chapter, exercise, evaluation, demonstration, etc. Standards exist that permit to describe a learning content in order to make it reusable (LOM[6], SCORM[7], AICC[8], etc.). Accessibility metadata may be added to these standards to make them respect the requirements of handicapped learners. We have to base our works on accessible content models inspired from the existing works of standardisation [9]. Furthermore, some of the WCAG recommendations may be included among these features.

The system functionality features Traditional e-learning environment, called Learning Management System (LMS) offers to the learner a set of tools that assist him during his learning process. It lets him navigate freely in the course structure, download and print documents, communicate with his colleagues and tutors with asynchronous tools as e-mail and forums and/or synchronous tools as chat and videoconference. Learner can learn accordingly to his appropriate rate of comprehension and perform pedagogical activities and interactive auto-evaluation exercises. These features have to be adapted in order to be used by a handicapped student. Some of the UAAG recommendations and the guidelines for developing accessible learning applications [9] have to be integrated to these features.

6) Instantiation example

Let us suppose the necessity of creating an e-learning platform for visually disabled people, in particular blind students. As shown in Figure 3 we use the general framework PIM composed by the common settings for all accessible e-learning platforms. For instance this PIM contains the classical student model, the LMS features, and the pedagogic content not dependent of any accessibility.

In addition we use the blindness PIM containing models of all the features for e-learning platform and content to be used by blind people. For example:

- The device model specifies the peripherals available for blind users: Braille terminal for text editing and text typing, voice recognition for commands, and speech synthesis for navigation. All the proposed models relative to these devices are associated to our generic framework.
- The interaction/presentation model: the definition of presentation/interaction principles used with available devices for blind users.
- The user model relative to blind users.

- The pedagogic content model: like the extension of the LOM model with meta data describing alternative presentation possibilities for the content. For example a video is tagged with metadata containing the alternative description of the video content.

The association of the two PIM's: the General framework PIM and the Blindness PIM give us a new e-learning PIM specific to blind users. From this PIM we have to create the transformation model to generate a PSM relative to the devices that will be used, for instance Braille modality, speech modality or multimodality. After that, source code is derived from the resulting PSM.

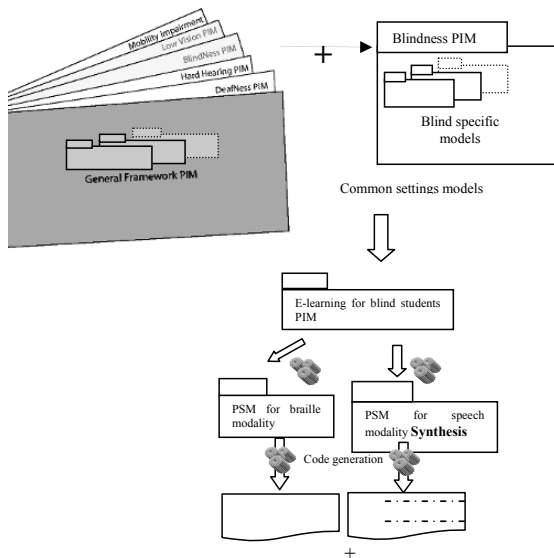


Figure 3: Instance for blind students

The last step is code generation. To illustrate this, there are many examples of possible mapping of some high-level perceptual concepts into primitives available on textual platforms such as XHTML or WML, and text to speech platforms such as JavaSpeech, Microsoft Speech API and Voice XML [10]. According to PSM for speech modality, we can take the following fragment of VXML example.

```
<?xml version="1.0"?>
<vxml version="2.0">
<form id="auteur">
<block>
<prompt> First course </prompt>
<audio src="http://.../audio/fc.wav">
</block>
</form>
</vxml>
```

The objective of our work is to increase accessibility to e-learning for disabled persons. Our approach is based mainly on the use of MDA. The advantages of the proposed MDA framework are the permanence of the specification models, the possibility to reuse existing models [11], and the originality of our work consists in using only the needed parts of a generic framework to generate specific content for a specific disability category and/or specific platforms / devices, etc.

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Two Different Approaches of Modeling the Teacher Relocation Problem in a Constraint Logic Programming System and Their Comparison

Nagehan Ilhan, Zeki Bayram

Computer Engineering Department, Eastern Mediterranean University
Famagusta, Turkish Republic of Northern Cyprus
{nagehan.ilhan, zeki.bayram}@emu.edu.tr

Abstract—We propose two ways of modeling the teacher relocation problem in the ECLⁱPS^c constraint logic programming system, implement them and compare their performance through simulation. The first one relies on logic variables that take on boolean values. The second one involves the use of the built-in predicates “element” and “occurrences.” Simulations confirm that the approach that uses the built-in predicates performs better in general.

I. INTRODUCTION

In [1] we defined the “teacher relocation problem,” and proposed a model for it in the constraint logic programming language ECLⁱPS^c [4] that made use of boolean-valued logic variables. The teacher relocation problem concerns school teachers wishing to relocate to other schools and who state their preferences in terms of which schools they want to move to. The problem, in simple terms, is to come up with a relocation scheme in which a utility function (the “happiness” of teachers) is maximized while not violating quota constraints of schools. This is an instance of the class of discrete optimization problems, and requires exponential search for its solution.

In this paper we improve upon our previous solution by adapting a different approach to modeling the problem, which makes use of two high-level built-in constraint predicates that are available in ECLⁱPS^c, namely the “element” predicate and the “occurrence” predicate. We compare the two solutions by running simulations using both models. We conclude that using high-level built-in constraint solving predicates is advantageous in this case compared to the previous solution of using Boolean-valued logic variables.

Constraint Logic Programming (CLP) is indeed very convenient for both modeling and solving discrete

optimization problems, since the problem can be formulated as a set of variables and constraints between these variables. The goal is to find an assignment of values to variables such that none of the constraints are violated. There can be a cost function which has to be minimized/maximized in the final solution. Once the model is set up, the built-in search and constraint solving mechanisms of the CLP system take care of the rest [2][3][5].

The remainder of this paper is as follows. In section II, we formally define teacher relocation problem. In section III we model it using two different strategies in ECLⁱPS^c, the first strategy being the one described in [1]. We then test both models under different scenarios in section IV. Results show that the modeling approach using built-in predicates outperforms the other one. In section V we have a brief survey of related work and finally in section VI we have the conclusion and future research directions.

II. DESCRIPTION, FORMAL SPECIFICATION AND TIME COMPLEXITY OF THE TEACHER RELOCATION PROBLEM

Each teacher who wishes to relocate can state two choices in order of preference. An implicit, but undesirable third choice on the part of the teacher is to stay in his/her current school. Teachers who do not wish to relocate do not make any choices, and are not forcibly relocated.

Teachers state their choices in order of preference. A specific teacher’s happiness is given very naturally by $order(teacher, assignment(teacher))$, where $order(t,s)$ is the position (first, second etc.) of school s in the preference declaration of teacher t . Here, smaller numbers mean more happiness.

The goal of the system is to maximize the overall happiness of teachers, which corresponds to minimizing the value of the objective function

$$\sum_{t \in \text{TeachersWhoWishToRelocate}} \text{order}(t, \text{assignment}(t)) \quad (1)$$

subject to the constraint in each school that the number of teachers at the school never exceeds its capacity (understaffing is a possibility, and occurs frequently in North Cyprus). This is modeled by the use of quotas, which specify the teacher deficiency (vacant positions) in each school before relocation is initiated. So for each school, the following constraint must be satisfied in a final solution:

$$\text{incomingTeachers} \leq \text{outgoingTeachers} + \text{quota} \quad (2)$$

Another obvious constraint is that a teacher cannot be assigned to more than one school, hence the function *assignment*.

For N teachers, the best case time complexity is N , where each teacher is assigned to his/her first choice without violating any constraints. For the worst case analysis, all possible combinations of assignments must be considered, which gives us 3^N .

III. TWO DIFFERENT MODELS USING CLP

In this section, two different models for the problem specified in Section II are presented, using the ECL^{PS} Constraint Programming Language. We start with the data structures used to represent teachers, their choices and school information.

A. Data Representation

To store the information about teachers, we use the structure *teacher*(*Teachername*, *ALSchool*) for each teacher. *Teachername* is the name of the teacher and *ALSchool* is the current school of the teacher. Each teacher name is assumed to be unique.

A teacher's choices are represented as *choice*(*Teachername*, *SchoolName*, *ChoiceNo*, *AppYear*), where *Teachername* is the name of the teacher, *SchoolName* specifies the name of the school which the teacher wants relocate to, *ChoiceNo* represents the order of preference of this school and *AppYear* is the application year of the teacher for relocation. So, *choice*('George Washington', 'Talented Kids High School', 1, 2005) would mean that George Washington's first choice would be to move to Talented Kids High School, and he first made his application to relocate in 2005.

Information about schools is given by *school*(*Schoolname*, *Countyname*, *Quota*, *MaxCapacity*), where *SchoolName* is the name of the school, *Countyname* specifies the county which the school belongs to, *Quota* is the number of vacancies at the school, and *MaxCapacity* specifies the maximum number of teachers which the school can employ.

```
solve(Cost) :-
    findall(X, teacher(X, _), Teacherlist),
    increment_loop(Teacherlist, 1, Cost), !.
```

Fig. 1. The "solve" predicate

Note that not all the information represented in the database is used in the solutions that we present, but they are included to allow the possibility of different utility functions in the future.

B. Techniques Common to Both Approaches

An incremental strategy is adopted in both approaches. First, an assignment is tried where only the first choice of each teacher is taken into account. If this does not yield a solution, then the first two choices are considered. If still no solution is generated, then the first three choices are considered (the third choice being implicit – stay at your own school, i.e. do not relocate). Our simulations in [1] confirm the advantage of using this incremental approach.

Another technique common to both approaches is the usage of a "base value" for a solution. A base value of the utility function is found for just *any* relocation scheme which does not violate the constraints. If a partial solution results in a utility function value that already exceeds the base value, then that branch of the search space is pruned. The base value is computed by the *solve1* predicate (used in Figures 2 and 3).

C. The First Modeling Approach

The main predicate in the program is *solve*, given in Fig. 1. Its output parameter *Cost* is the minimum cost of the solution if it exists. The solution itself is printed on the screen. *solve* generates the teacher list using the database, and passes it on to the *increment_loop* predicate, which actually does the job. The second actual parameter of *increment_loop* denotes that only the first choices will be considered when the search begins. *increment_loop* implements the incremental search technique.

The *increment_loop* predicate definition, given in Fig. 2, gets *Teacherlist* and *Minhappiness* as input parameters and outputs the *Cost*. Predicate *willbelabeled* generates the list *Clist1*, which will be flattened by the *flatten* predicate to generate a list of the form [(*Teachername*, *Schoolname*, *R*, *Cost*), ...] in its *Clist1* output parameter. The domain of *R* is [-1,0] if *Schoolname* is either a school preferred by *Teachername* or it is his/her current school. Otherwise the domain of *R* is [0].

This is the main point of difference between this approach and the next: here we use -1 to represent that a teacher is assigned to a school, and 0 that s/he is not (our choice of -1, rather than 1, to represent a teacher being assigned to a school is technical and is not of major importance: the built-in *indomain* predicate assigns values to variables in

```

increment_loop(Teacherlist,
               Minhappiness, Cost):-
    willbelabeled(Teacherlist, Minhappiness,
                 [], Clist1),
    flatten(Clist1, Clist),
    each_teacher(Teacherlist, Clist),
    findall(Y, school(Y, _, _), Schoollist),
    createoutoflist(Teacherlist, Schoollist,
                   [], Outlist, Clist),
    flatten(Outlist, Outoflist),
    findinginoutlist(Schoollist, Clist,
                    [], Schoolinlist),
    findinginoutlist(Schoollist, Outoflist,
                    [], Schooloutlist),
    quotaconstraint(Schoollist, Schoolinlist,
                   Schooloutlist),
    solve1(RefCost),
    length(Teacherlist, LT),
    bb_min(our_labeling(Clist, 0, RefCost,
                       Cost), Cost, bb_options with
           [from:LT]),
    (nonvar(Cost), showreplacement(Clist, !);
     (Minhappiness1 is Minhappiness+1,
      increment_loop(Teacherlist,
                    Minhappiness1, Cost))).

```

Fig. 2. The “increment_loop” predicate for the first approach

increasing numeric order, and in our labeling predicate this would result in a teacher *not* being assigned to a school). In the second approach, we shall use the built-in `element` constraint predicate.

Then `each_teacher` predicate is called. It gets `Teacherlist` and `Clist` as input. It is the first constraint of the program which constrains a teacher to locate only to one school. A teacher cannot exist in more than one school at the same time. In order to prevent the relocation of a teacher to more than one school, the sum of all the R values of each teacher in `Clist` is constrained to be -1.

$$\text{SumofRs} \# = -1 \quad (3)$$

We also need to make sure that the constraint

$$(\text{Incoming}-\text{Outgoing})\# \leq \text{Quota} \quad (4)$$

is not violated for any school. The `quotaconstraint` predicate achieves this. It takes `Schoollist`, `Schoolinlist`, and `Schooloutlist` as parameters. It constrains each school such that the difference between the number of incoming teachers and outgoing teachers to the school is smaller than or equal to the quota of the school. Its parameters are generated as follows: The list of schools `Schoollist` is generated and passed as an input parameter to the `createoutoflist` predicate, together with `Teacherlist` and `Clist`. The predicate `createoutoflist` generates the `Outlist`, flattened into `Outoflist`, which has the same structure as `Clist`, except that the R value of a teacher becomes -1 in the school which he/she wants to move out from.

`Outoflist` contains information about which schools teachers are moving out of.

Then `findinginoutlist` predicate is called two times. In first call, it takes `Schoollist` and `Clist` as input parameters and generates `Schoolinlist` as output. It keeps the information of the number of coming teachers to each school and has the structure `[(Schoolname, NumberOfComingTeachers),...]`. In second call of the `findinginoutlist` predicate, `Schoollist` and `Outoflist` are passed as input parameters to generate `Schooloutlist` which has the same structure with `Schoolinlist` but keeps the number of outgoing teachers for each school: `[(Schoolname, NumberOfOutgoingTeachers)]`.

The `solve1` predicate is then called to get a baseline cost in its `RefCost` parameter. `solve1` just finds any feasible solution, without any consideration of optimality. We use this value to prune the search space when we make incremental assignments: if the current “cost” has already exceeded the reference cost, that branch of the search space is not explored any further. `Refcost` is passed as a parameter to `our_labeling` predicate, which performs assignments to teachers, keeping track of the value of the utility function (happiness of the teachers).

Next we have a call to the minimization predicate `bb_min(Goal, Cost, Options)`. `bb_min/3` is a built-in predicate which finds a solution of the `Goal` that minimizes the value of `Cost` [4]. The goal to be satisfied is `our_labeling(Clist, 0, RefCost, Cost)`, where `Cost` is to be minimized. In our case, `Cost` is the cumulative happiness of teachers, as already discussed.

Then we have an OR (;) structure. If the program has already found the minimum cost, the `showreplacement` predicate is called, which prints the teacher names, their assigned schools, as well as the rank of the school in the preference order of the teachers. If no solution was found, the `Cost` variable is free, `Minhappiness` is incremented by 1 and `increment_loop` is called recursively to try to find a solution by including one more preference of the teachers to the search space.

D. The Second Modeling Approach

Similarly to the first approach, the main predicate is `solve` and the parameter `Cost` is the minimum cost of the solution (Fig. 1). The teacher list generated by the `solve` predicate is passed on to the `increment_loop` predicate, given in Fig. 3. The `increment_loop` predicate calls the `for_each_teacher` predicate that constrains the teacher choices with the value of `MinHappiness` and generates a `List` of the form `[(Teachernamei, Happinessi, Schooli),...]`. The `for_each_teacher` predicate assigns a school from the list of teacher choices for each teacher using built-in predicate `element`. The `element` predicate has signature

```

increment_loop(Teacherlist,
               MinHappiness, Cost) :-
    findall(Y, school(Y, _, _), Schoollist),
    for_each_teacher(MinHappiness,
                    Teacherlist, [], List),
    coming_teacher_list(List, [], ComersList),
    outgoing_teacher_list(Teacherlist,
                         [], OutgoingList),
    constraint_quotas(Schoollist, ComersList,
                     OutgoingList),
    solve1(RefCost),
    length(Teacherlist, LT),
    bb_min((our_labeling(List, RefCost, 0,
                        Cost)), Cost, bb_options with
          [from:LT]), !,
    ((nonvar(Cost), showreplacement(List), !);
     (MinHappiness1 is MinHappiness+1,
      increment_loop(Teacherlist,
                    MinHappiness1, Cost))).

```

Fig. 3. The “increment_loop” predicate for second approach

element(?Index, ++List, ?Value), where *Value* is the *Index*'th element of the integer list *List* [4]. The *for_each_teacher* predicate makes a call to *element* (*Happiness1*, [*FirstSchool*, *SecondSchool*, *CurrentSchool*], *School1*). The *School1* variable shows which school *Teacher1* is tentatively assigned to and *Happiness1* is the order of *School1* among the choices of *Teacher1*. As mentioned above, this is the main difference of the two approaches.

Then we have the following constraint, which implements the incremental search technique.

$$Happines_i \#=< MinHappiness \quad (5)$$

It constrains teacher *i* to be assigned to the first, first two, or first three choices, in that order (again, the third choice is the implicit “stay at your current school” option).

The *coming_teacher_list* predicate gets the *List* as an input parameter and generates *ComersList* which has the structure of [(*Teachernamei*, *AssignedSchooli*)]. This list depicts which teacher is assigned to which school. Similarly the *outgoing_teacher_list* predicate gets *Teacherlist* as an input parameter and generates *OutgoingList* which has the structure [(*Teachernamei*, *VacatedSchool*)].

Then, as before, we need to make sure that the capacity of each school is not exceeded in an assignment. The *constraint_quotas* predicate does this (Fig. 4). It takes *Schoollist*, *ComersList*, *OutgoingList* as input parameters and constrains each school such that the difference between the number of incoming teachers and outgoing teachers to the school does not exceed the quota of the school. The *occurrences/3* built-in predicate is used to determine the number of incoming and outgoing teachers to each school (the number of times a school *occurs* in the list of schools to which teachers are relocated is computed using this built-in predicate; similarly with outgoing teachers).

```

constraint_quotas([], _, _).
constraint_quotas([H|T],
                 Comers_list,
                 Outgoing_list) :-
    pred1(Comers_list, [], Comers_list1),
    pred1(Outgoing_list, [], Outgoing_list1),
    occurrences(H, Comers_list1, NewTeachers),
    occurrences(H, Outgoing_list1,
               OutgoingTeachers),
    school(H, _, Quota, _),
    NewTeachers - OutgoingTeachers #<= Quota,
    constraint_quotas(T, Comers_list,
                     Outgoing_list).

pred1([], A, A).
pred1([_ (H, S) | T], Acc, Acc2) :-
    append(Acc, [S], Acc1), pred1(T, Acc1, Acc2).

```

Fig. 4. The “constraint_quotas” predicate

The predicate *occurrences* has signature *occurrences(+Value, +List, ?N)* and constrains its arguments such that *Value* occurs exactly *N* times in *List* [4].

The remainder of the *increment_loop* predicate is the same as the one in the first approach.

IV. COMPARISON OF THE TWO APPROACHES

We simulated both approaches to see the difference in their performance. We generated instances of the problem for different number of teachers and quotas in schools. The number of schools was fixed at 10. For a specific number of teachers, the program corresponding to each approach was run multiple times, where in every run the number of empty slots in each school was randomly determined from 1 up to a maximum number. The average time taken to find the optimum solution for a specific number of teachers was then noted for either approach.

Fig. 5 depicts the performance of the two approaches where the number of vacant slots in each school varies randomly from 1 to 5.

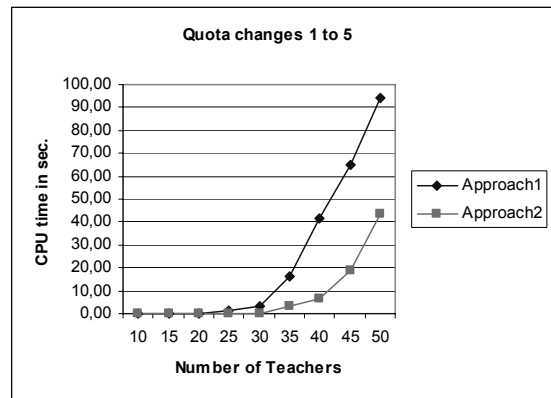


Fig. 5. Number of Teachers vs. CPU time - quota changes from 1 to 5

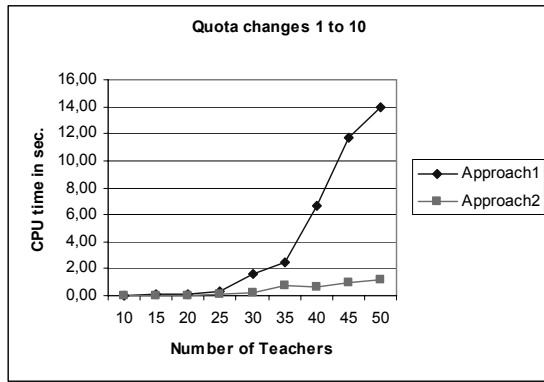


Fig. 6. Number of Teachers vs. CPU time - quota changes from 1 to 10

It is clearly seen that approach 2 takes less time, by a factor of 2 for 50 teachers, to solve the problem.

The solution of the problem becomes easier when we increase the number of empty slots in each school, because the teachers can be assigned more easily, possibly without requiring the relocation of other teachers from a school. In Fig. 6, the number of empty slots varies randomly from 1 to 10. We see that either approach requires far less time now to solve the problem, but the second approach still outperforms the first, and even to a greater degree (a factor of almost 14) than when the quotas changed from 1 to 5.

Fig. 7 depicts the worst case scenario, where empty slots of the schools are all zero. Approach 2 still performs better. However, it is not possible to obtain a solution in a reasonable amount of time when the number of teachers exceeds 30 using either approach. This is to be expected, given the exponential nature of the search space.

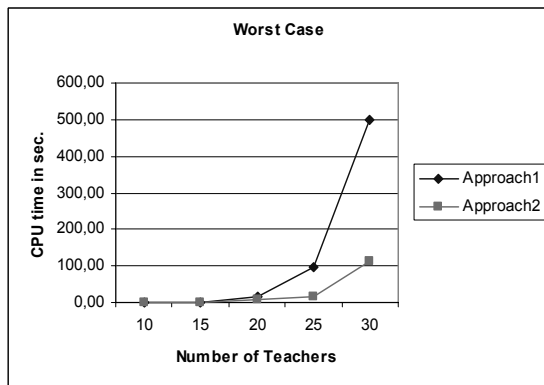


Fig. 7. Number of Teachers vs. CPU time - all quotas zero

V. RELATED WORK

Solution of many kinds of scheduling problems has been attempted using Constraint Logic Programming. We have not found, beside ours in [1], any that attempts to solve the teacher relocation problem in literature though. In [6], the Hospitals/Residents Problem is presented, which bears some resemblance to the teacher relocation problem. In the Hospitals/Residents Problem, each resident is paired with an acceptable hospital, in such a way that a hospital's capacity is never exceeded. Both the hospitals and residents have preferences, and a "stable" matching is attempted, where neither the resident, nor the hospital, would rather be paired with something/someone else. The authors investigate four different techniques, two of them being similar to our assignment of binary values to variables in first approach.

In [7], the author presents a solution to sport tournament scheduling using the finite domain library of ECL'PS[®]. He makes use of a constraint-based depth-first branch and bound procedure. The optimal solution is found in reasonable time except in some situations. He also proposes a local search procedure in order to provide an approximate solution in shorter time. The authors in [7] examine incremental search in AI applications by focusing on Lifelong Planning A*. In [9] the authors present a methodology to solve a job-shop scheduling problem using constraint logic programming. They investigate a new strategy to find the optimal solution which involves step by step decreasing of the upper and lower bounds of the search space of the branch and bound evaluation function. The authors in [10] present a solution to university timetabling problem using the ECL'PS[®] constraint logic programming language by stating the constraints in the most suitable order.

VI. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

We modeled the teacher relocation problem, defined originally in [1], using two different approaches in the constraint logic programming system ECL'PS[®] and compared their performance under different scenarios. The first approach uses logic variables with boolean values. The second approach uses the built-in predicates "element" and "occurrence." In both approaches, incremental search and pruning techniques are used to speed up the solution process. Simulations confirm that the approach that uses the built-in predicates performs better in general. This result probably should not come as a surprise, given that built-in predicates are expected to be implemented to perform efficiently.

For future work, given that the framework is already established, we envisage making the utility function much more representative of the interests of all involved, such as schools, the ministry of education and even parents. A WEB interface can be used to accept the preferences of all parties involved.

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A CONTINUOUS UNSUPERVISED ADAPTATION METHOD FOR SPEAKER VERIFICATION

Alexandre Preti^{1,2}, Jean-François Bonastre¹, François Capman²

¹LIA, 339 chemin des Meinajaries
84911 Avignon Cedex 9, France
{alexandre.preti,jean-francois.bonastre}@univ-avignon.fr

²Thales, MMP Laboratory, 160 Bd Valmy
92700 Colombes, France
francois.capman@fr.thalesgroup.com

Abstract—This paper deals with unsupervised model adaptation for speaker verification. We proposed a new method for updating speaker models using all test information incoming in the system. This is a continuous adaptation method which relies on the probability of the test trial belonging to the target speaker. Our adaptation scheme is evaluated in the framework of the NIST SRE 2005. This approach reaches a relative improvement for the NIST unsupervised adaptation mode of 15% DCF and 35% EER.

I. INTRODUCTION

Gaussian Mixture Models (GMM) based systems for speaker recognition are widely used in speaker recognition applications due to their robust performance [1]. Despite new normalization techniques such as Bayesian Factor analysis [2], GMM based speaker verification systems show their limits when limited enrollment data are available. A way of passing through this problem is to increase this amount of data by using test information [3,4,5]. Indeed during the normal use of the verification system some test trials are true target trials and could be added to the enrollment data. This is known as unsupervised adaptation.

Moreover, adding information coming from the use of the system can improve the robustness of the system in terms of speaker and channel variabilities as the speaker voice and the recording conditions could change with time. Interest on unsupervised adaptation has grown in the community and many speaker verification systems using this technique have appeared in the past years (NIST unsupervised adaptation task [6]).

Results of supervised adaptation show that a huge improvement could be reached, but State of the Art methods in unsupervised adaptation are far from such improvement [7, 8, 9]. The main drawback of unsupervised adaptation technique remains the difficulty to set a decision threshold for selecting the trials. To solve the problem we proposed a new continuous adaptation method that uses all the test information to update the target model. The influence of a given test segment in the new target model is weighted according to its probability to belong to the target.

Section 2 describes the unsupervised adaptation principle.

Section 3 introduces database, tools and protocols used to set up experiments. Experimental results are presented in section 4. Finally, conclusions are given in section 5.

II. UNSUPERVISED ADAPTATION

A. State of the Art methods

The main idea for unsupervised speaker model adaptation is to detect during the system use the true target trials and to adapt the model using this material. Of course, in order to not deteriorate the target speaker models, as less as possible impostor trials should be selected.

Unsupervised adaptation is mainly done as follows:

- Log Likelihood Ratio of the trials given the target model is computed,
- some normalization techniques are applied (TNORM [10]),
- if the test score is above a threshold, the test is kept for adapting the corresponding target model.

The adapted target model is usually obtained from a MAP adaptation of the UBM with all selected materials or from MAP adaptation of the previously trained target model [7]. Some works proposed also to vary the regulation factor used for MAP adaptation according to the available quantity of data [8] (reaching an improvement). If unsupervised adaptation is quite attracting, promising large improvements, the comparison with supervised adaptation still reveals large difference in terms of performance [8, 9]. The gap between supervised and unsupervised adaptation could be explain by the fact that the test segment selection thresholds are very conservative in order to avoid the selection of an impostor trial which could damage the target model (and the speaker verification system performance consequently). In this case, the amount of selected trials is not large and adaptation does not occur very often. Moreover, the high threshold leads to select data already well recognized by the target model (high LLR). Consequently the added data will bring few interesting and new information in terms of speaker or channel characteristics. The useful data we expect to use for adaptation are the ambiguous data, where the acceptance decision is not straightforward, represented in the aliasing area between the target and the impostor distributions (see fig. 2). Finally the

optimum adaptation threshold is very hard to determine. As the amount of data increases when creating the new target models, the best decision threshold changes. A way of bypassing the problem is to select the trials using always the initial target model (learnt on a one session record) but obviously it is not optimal [9].

B. Proposed approach

The work described in this paper intends to integrate trials for which the acceptance decision is ambiguous in the adaptation set. It also intends to avoid the problem of setting a hard decision threshold for adaptation. The proposed method consists in adapting the target model with all the data gathered from the real life of the system. A weight is assigned to each test and is used in the computation of the Maximum Likelihood estimate (EM algorithm) when updating the new target model. This weight is the *a posteriori* probability of the trial belonging to the target.

To compute these probabilities we use a 2 class Bayesian classifier (target/impostor), World MAP (WMAP) [11]. We obtain the *a posteriori* probability of having a target (of a class) given the *a priori* target and impostor score distributions of the verification system (LLR). It takes also into account the prior probability of both classes. WMAP is defined as follows:

$$P(x=y) = \frac{P(s|x=y).P(x=y)}{P(s|x=y).P(x=y) + P(s|x \neq y).P(x \neq y)} \quad (1)$$

where $P(x=y)$ is the prior probability of a target trial, $P(x \neq y)$ is the prior probability of an impostor trial, $P(s|x=y)$ is the likelihood of the score (LLR) given the target score distribution, $P(s|x \neq y)$ is the likelihood of the score (LLR) given the impostor score distribution.

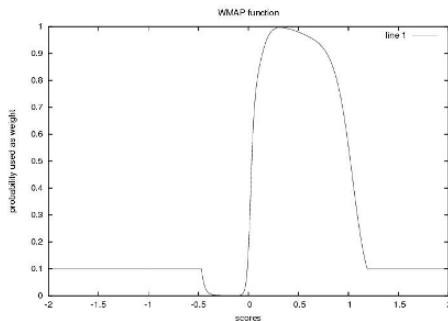


Figure 1: WMAP function for scores between -2 and 2

We can notice that WMAP outputs a fixed probability (equal to the prior probability of a target trial) when the observed score is outside the learned target and impostor score

distributions, i.e., when the score is very low or very high (see fig. 1).

The score distributions (see fig. 2) are modelled using 12 component GMM learnt on a development data set (NIST SRE 2004 database).

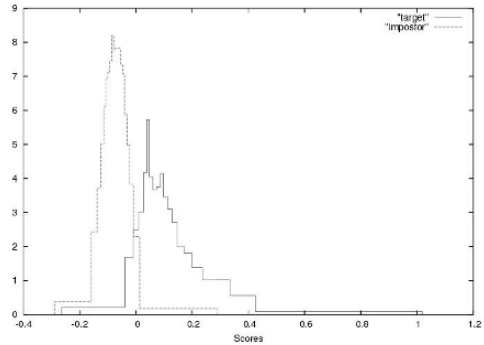


Figure 2: NIST SRE 2004 target and impostor score distributions

The target model is adapted from the UBM using the initial training segments of the speaker (weight = 1) and the test segments with their corresponding weights. A traditional Bayesian adaptation algorithm (MAP) [12] is used with a regulation factor of 14 (mean parameters only are adapted).

III. TOOLS AND PROTOCOLS

A. Database

All the experiments presented in section 4 are performed based upon the NIST 2005 database, all trials (det 1), 1conv-4w 1conv-4w, restricted to male speakers only.

This condition consists of 274 speakers. Train and test utterances contain 2.5 minutes of speech on average (extracted from telephone conversations). The whole speaker detection experiment consists in 13624 tests, including 1231 target tests and 12393 impostors trials. The priors used for WMAP are 0.1 for target and 0.9 for impostors. From 1 to 170 tests are computed by speaker, with an average of 51 tests.

B. Baseline speaker recognition system

The LIA_SpkDet system [13] developed at the LIA lab is used as baseline in this paper. Built from the ALIZE platform [14, 15], it was evaluated during the NIST SRE'04, SRE'05 and SRE'06 campaigns, where it obtained good performance for a cepstral GMM-UBM system. Both the LIA_SpkDet system and the ALIZE platform are distributed under an open source licence.

The LIA_SpkDet system is based on classical UBM-GMM and Tnorm approach for likelihood score normalization. For the background model, the train set is composed of records from 1464 male speakers taken from a part of the fisher corpus. More precisely, only speakers having a unique conversation have been used, resulting in 1464 selected speakers (male only). Concerning Tnorm, a cohort of 160 - target- male speakers of NIST SRE 2004 database has been used. For the front-end processing, the signal is characterized by 50 coefficients including 19 linear frequency cepstral coefficients (LFCC) issued from a filter-bank analysis, their first derivative, 11 of their second derivative and the delta energy. The parameterization is done with SPRO [16]. An energy-based frame removal is computed (the energy is modelled by a 3 component GMM [17]). A mean and variance normalization process is applied on coefficient. A gender-dependent feature mapping [18] process is applied to all the data for channel robustness. Three channel conditions have been used (landline, cellular, cordless). All channel dependent models are derived from the UBM using MAP adaptation (mean and variance). The UBM and target models contain 2048 Gaussian components. LLR scores are computed using the top ten components.

The performance is evaluated through classical DET performance curves [19] and decision cost function (DCF).

C. Protocol description

The two protocols described here were already presented and more detailed in [9].

1) Batch protocol:

This experimental protocol allows to adapt a target model with all the trials involved with it. The new target model is computed using all the test information; next, the LLR scores for each test are computed using the adapted speaker model.

2) Nist protocol:

The Nist unsupervised adaptation mode allows to update target models using previously seen trial segments (including the current segment) before to take the decision on the current trial segment. It is required to follow the order of the trials in the test protocol [6].

For each test, a LLR is computed using the test data and the corresponding adapted target model.

D. Score normalization

It is well known that the amount of training data plays an important role for the Tnorm approach [20], i.e. performance are better when the amount of data for training the target speaker models is similar to the one used for training Tnorm impostor models. Using the unsupervised adaptation the amount of data used to estimate the target model varies test by test (or by set of tests for the batch protocol). In order to give a first evaluation of this issue on the system performance, we

computed an "adapted Tnorm" cohort. The corresponding Tnorm models are estimated on NIST SRE 2004 database using the batch unsupervised mode.

IV. RESULTS

Experimental results obtained for the unsupervised adaptation method are presented below.

A. Batch unsupervised protocol

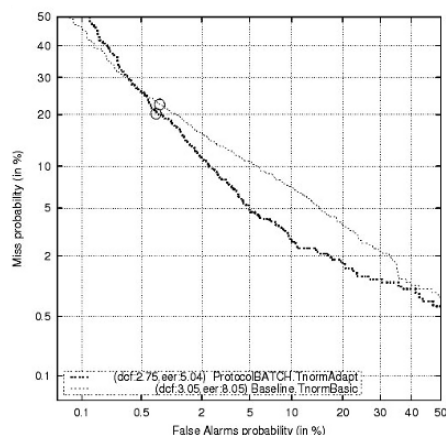


Figure 3: DET curves for the Batch unsupervised protocol (adapted TNORM cohort) and baseline (basic TNORM cohort)

The results for the system using the Batch protocol are presented in figure 3. Performance of the baseline system is also presented for comparison. This method reaches a 10% DCF and 37 % EER relative improvement.

If we look at the difference in terms of right or wrong decisions, presented in Table 1, we can notice that the Batch protocol accepts nearly 5% more (good) target trials than the non adaptative system (975 true target trials accepted for the unsupervised adaptation system compared to 952 for the baseline). It accepts also less impostor trials.

B. Nist unsupervised protocol

The results for the system using the Nist protocol are presented in figure 4. Performance of the baseline system is also presented for comparison.

Our method allows a 15% DCF and 35 % EER relative improvement. Regarding Table 1, the number of true acceptance is increased by nearly 12%, from 952 for the baseline to 1040 for the Nist protocol.

But some degradation of the target models during the adaptation occurs and some additional false acceptance errors are noticed (63 false reject and 91 false acceptance added).

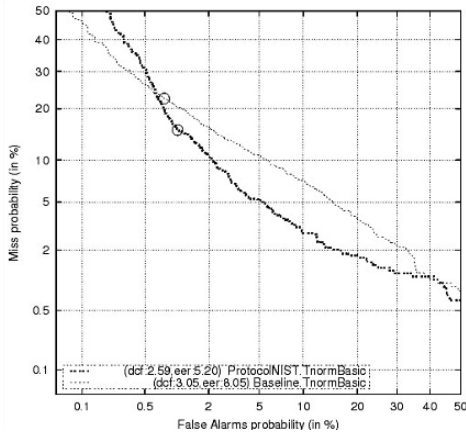


Figure 4: *DET curves for the Nist unsupervised protocol and baseline (basic TNORM cohort)*

	Nist protocol	Batch protocol
Target trials accepted	1040	975
Impostor trials accepted	130	89
False reject added	63	39
True reject added	58	43
True acceptance added	151	62
False acceptance added	91	35

Table 1: *Information on unsupervised adaptation behavior (total trials: 13624, target trials: 1231, impostor trials: 12393). Baseline reference: 952 target trials accepted, 97 impostor trials accepted. For all the systems, we use the optimum a posteriori decision threshold.*

C. Basic Tnorm vs adapted Tnorm

This section gives an overview of the different Tnorm effects on the two unsupervised systems. The table 2 presents the different results using the two Tnorm cohorts.

We can notice that the adapted Tnorm performs well for DCF for the two adaptation protocols. Nevertheless, using the adapted Tnorm for the Nist protocol leads to a significant loss in terms of EER (36% relative loss).

We can also notice that the basic Tnorm is not well suited for the Batch protocol in terms of DCF (see III.D). However it performs well for EER.

	DCF	EER (%)
Batch protocol adapted Tnorm	2.75	5.04
Batch protocol basic Tnorm	2.98	4.47
Nist protocol adapted Tnorm	2.53	8.14
Nist protocol basic Tnorm	2.59	5.20

Table 2: *EER and DCF for the Batch and Nist unsupervised adaptation protocols using the two different Tnorm cohort.*

D. Fusing scores of systems

This section proposes a fusion experiment between our baseline system (defined in section III.B) and the system with unsupervised adaptation mode for both protocols, Batch and Nist.

The combination presented here is performed by computing an arithmetic mean of Tnorm scores of two different systems. The best fusion reaches a gain of 24% and 39.5% DCF and EER respectively for the baseline fused with the Nist protocol (fusion weights 0.5 0.5, see fig. 5) compared to the baseline alone.

Experimental results obtained with the various adaptation protocols are summarized by table 3.

	DCF	EER (%)
Baseline	3.05	8.05
Batch protocol	2.75	5.04
Nist protocol	2.59	5.20
Fusion Nist-Baseline	2.32	4.87
Fusion Batch-Baseline	2.83	5.77

Table 3: *EER and DCF of (1) the baseline system (2) Batch unsupervised system (3) Nist unsupervised system (4) Fusion Nist-baseline (TNORM scores, see III.D)*

V. DISCUSSION

In this paper a new method for unsupervised target model adaptation in the framework of a speaker detection system was presented. The proposed adaptation algorithm uses a

continuous adaptation process instead of classical threshold based technique was presented. It was evaluated using the NIST SRE 2005 database and showed its potential as it reduces significantly DCF and EER (up to 15% DCF and 35% EER relative improvement for the NIST protocol and 10% DCF and 37% EER relative improvement for the Batch protocol). We proposed two different adaptation processes that reach nearly the same improvement but which differ in terms of error handling. Two Tnorm cohorts were also presented. We showed that gains on DCF or EER rely on the use of the appropriate cohort for Tnorm score normalization.

Results of previous work on unsupervised adaptation using a classical threshold based method [9] and the improvement showed in this paper highlight the need of data with variability for updating the speaker model. It also shows that using a threshold on scores for selecting the target trials seems not well suited to select the useful data for enriching the speaker models.

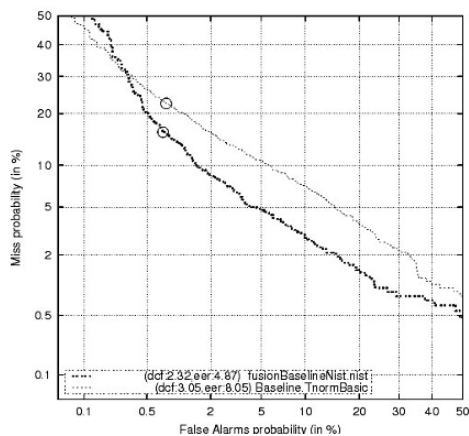


Figure 5: DET curves for the fusion system and the baseline, (NIST protocol, basic TNorm cohort)

Future works will be focused on a better *a priori* score distribution estimation (using Tnormed scores for example) and on adapting the speaker detection decision threshold when the unsupervised adaptation mode is used.

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