A case study of an enriched classroom model based on the World Wide Web

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An enriched classroom model based on the World Wide Web (WWW) was developed at the Software Engineering Laboratory of the National Technical University of Athens as part of a European partnership project entitled An Experiment in Open and Distance Learning using New Technologies *(EONT). The purpose of the EONT project was to evaluate the effectiveness of the use of new technologies (specifically the Internet and the WWW) as a supplementary instruction delivery mode for overcoming the constraints in time and place imposed by conventional classroom based teaching. The enriched classroom model developed is described in this paper, as well as the methodology that was followed for its evaluation. The results of the qualitative analysis are also presented along with the lessons learned and the revisions made to the model as a result of this evaluation.*

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Introduction

The Software Engineering Laboratory (SEL) of the Electrical and Computer Engineering Department at the National Technical University of Athens (NTUA) has offered an introductory course in Software Engineering since 1986. It is primarily targeted at undergraduate students in their ninth semester. The structure of the course is based on a two-hour lecture session, a one-hour discussion session and a two-hour practice session taking place in the laboratory every week. Students gain practical experience by working collaboratively in small groups on reasonably large projects. The study material consists of a textbook entitled *An Introduction to Software Engineering*[1], written in Greek, along with some review papers from the recent literature.

The conventional mode of teaching, however, faces major problems[2]:

- Lecture attendance decreases. More specifically, the percentage of students actually attending the classroom sessions is less than 50%. The main reason is that some of the students have already job obligations.
- It is difficult for students to ask questions and receive help with problems outside of the instructor's appointed office hours.
- There is little interaction in the classroom. Students are often overly shy and prefer not to ask questions.
- The curriculum of the course changes so rapidly that the textbook quickly becomes obsolete.

A remedy to these problems seemed to be to combine open learning techniques based on new technologies such as the Internet and the WWW with traditional classroom teaching. On the one hand, open learning is a way of overcoming the constraints of time and place imposed by traditional classroom based delivery. On the other hand, the growth of the Internet and the WWW, coupled with a decrease in the cost of hardware, offers real challenges for their use in the classroom. Although the use of open learning techniques based on new technologies in a classroom setting seems plausible, the effectiveness of such a combination remains to be examined.

To begin to answer this question, a European partnership project called *An Experiment in Open and Distance Learning using New Technologies (EONT)* was set up in 1995 as part of the Socrates-ODL programme[3]. The EONT project was launched for a two-year period (December 1995–August 1997) and its primary aim was to investigate the effectiveness of the use of new technologies for open learning in the higher education sector[4]. For the purpose of the project, each partner created courseware conforming to the WWW client-server architecture. The courseware was stored in computers running a second generation networked hypermedia server called HyperWave[5] and accessed by multimedia client computers.

At the SEL, an enriched classroom model based on the WWW was developed. The term *enriched* signifies that the open learning delivery mode was used to complement the traditional one[6,7]. In addition to the course textbook, courseware in the form of online hypermedia learning material was produced which could be accessed from any place with a direct or indirect (via modem) Internet connection. The main intention was to make the learning process more flexible, stimulating and available around the clock. The open learning part of this enriched model was implemented through an open learning system based on WWW (hereafter referred to as the Web-OL system). In this paper, the enriched classroom model, the Web-OL system and the evaluation results are described.
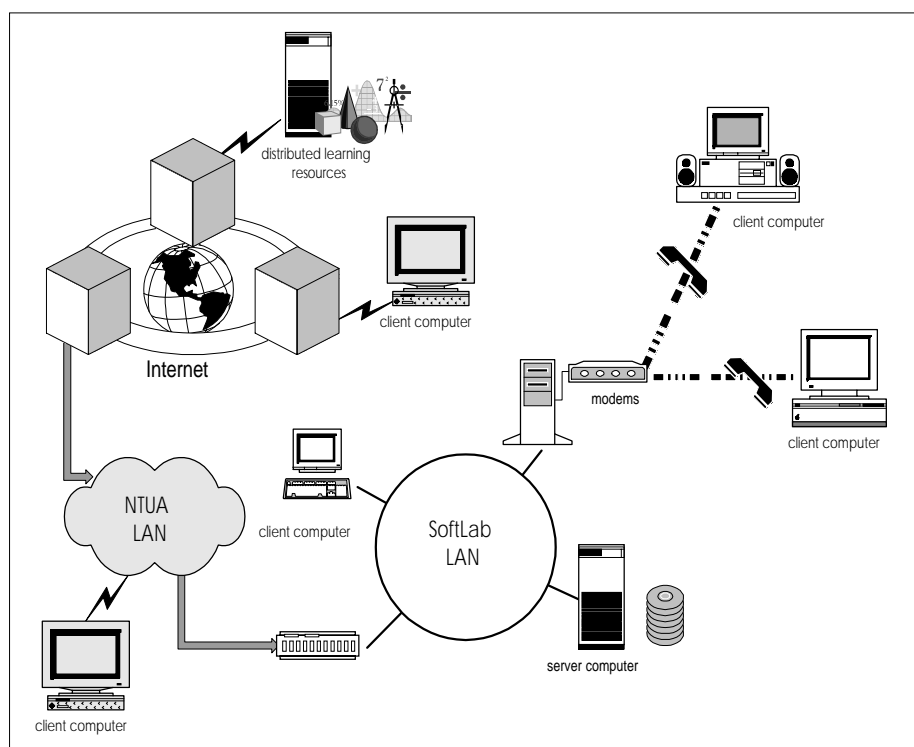
Figure 1: Components of the Web-OL system

The structure of the paper is as follows: in the next section, the implementation approach and a description of the enriched classroom model are given and the Web-OL system and its components are illustrated. In section three, the method used to evaluate the learning effectiveness of this model is described. The major evaluation results, with particular reference to the qualitative ones, follow in section four. The revisions which needed to be made to the enriched model are presented in section five.

The enriched classroom model and the Web-OL system

The WWW can be used in various ways in education and models have been developed for various distinct pedagogical purposes. These models have been categorised as:

- *information based models* (the WWW is used for retrieving information, as in virtual museums or digital libraries);
- *teaching media based models* (the WWW is used only for dissemination of educational material to distance students: course descriptions, educational software and so on);
- *enriched classroom models* (OL techniques with the aid of the WWW are used to complement traditional classroom-based teaching);
- *virtual classroom models* (the WWW is used with emphasis on collaboration and computer mediated human interaction)[8].

At the SEL, an enriched classroom model was developed, tested and evaluated during the academic year 1996-1997. The WWW was used to *add value* to the teaching and learning processes as well as to provide a flexible, stimulating and effective learning environment for open learning[9]. According to systems theory[10], an open

learning system consists of components (subsystems) such as the technological infrastructure, the actors involved in the teaching and learning process (instructors/tutors, learners, technical/administrative staff), the course material and the learning location (where learning occurs – university, workplace, home). Each learning location supports different learning methods and requires different settings in order that the learning objectives can be achieved[11-14].

The system's components are closely interwoven. When dealing with one component, it is necessary to take the other components into account as well, keeping in mind the system as a whole. For example, the designer of the course material needs to take into consideration the technological infrastructure and the restrictions imposed by it and the roles of the actors in the OL system, as well as the places where learning will take place, because these also impose restrictions and require specific settings.

Figure 1 illustrates the technological infrastructure of the Web-OL system which was used to implement the open learning part of the enriched classroom model developed at the SEL. This infrastructure consisted of a Hyperwave second generation WWW server[15], the Internet, one server computer and several client computers. The server hosted the online learning material, data about students and instructors (personal data and records) as well as data used for course management. The actors and their roles in this model are shown in Figure 2.

The WWW-based part of the enriched classroom model was designed to be learner-centred. The roles of the actors in the Web-OL system were based on cognitive theories of instruction that emphasise the centrality of the learner's activity[16]. The learners are expected to seek and choose from information available at their own pace and according to their own needs and preferences. The instructor is a facilitator and a guide for the learning

process[17].

The learning material for the course *An Introduction to Software Engineering* consisted of several parts as follows:

- offline material;
- textbook;
- review papers;
- online courseware;
- hypermedia course notes (the structure of the content follows the UK's Open University standards for organising the learning material into blocks and units);
- case study (executable computer program and documentation of a case study whose subject is quite similar to the subject of the team projects);
- description of the team projects.

The courseware was designed to be flexible and user-friendly[18]. An ordinary WWW browser (such as Netscape or Internet Explorer) was adequate to view the material. The students could access the material either from the computers of the SEL or from their home or workplace, provided that they had access to the Internet. This variety of learning locations was necessary in order to monitor the effectiveness of the model in circumventing the place and time constraints of learning. Moreover, the new generation of browsers (such as Netscape 4.0) incorporate email facilities which enable the exchange of messages between students and tutors from the same run-time environment.

Evaluation approach

Subjects

Fifty (8 women and 42 men) of the 61 students registered for the course responded to the evaluation questionnaire. Of these students, 4% indicated that they were computer novices, 30% had some experience, 44% were reasonably experienced and 22% had professional experience. In terms of time spent working with the Web-OL system, 48% spent less than one hour, 38% from one to two hours, and 14% from three to four hours per week.

Instruments and data analysis

Summative evaluation was performed to deduce the learning effectiveness of the use of the enriched class-room model. This followed the *pre-test* and *post-test*

approach[19, 20]. Two kinds of questionnaire were given to the students[21]. The first one (the pre-test) aimed at identifying the learners' expectations. It consisted of twelve questions and was administered during the first days of the course delivery but not later than the first week. The post-test questionnaire helped to elicit overall judgements and criticism of the model. The questions which appeared in the pre-test questionnaire were replicated in the post-test in a rephrased form. However, the latter instrument consisted of a large number of closed-end questions which were used to evaluate specific issues such as course design, human-interaction, and so on.

The data collected from the post-test questionnaire was analysed using quantitative and qualitative methods. A composite variable called *learning effectiveness* was developed to measure the overall learning effectiveness of the enriched classroom model. Twenty-three questions (items) formed this composite variable. These items included dimensions of students' cognitive and attitudinal outcomes.

The criteria for choosing the items for which comprised the variable *learning effectiveness* were:

- *appropriateness*: the enriched classroom model was appropriate to the student body for which it was intended (taking into account issues such as preparedness for study, expectations, aims and objectives);
- *engagement*: the student found the enriched classroom model interesting, challenging, flexible;
- *students' performance*: students increased their knowledge and skills, developed new learning habits[22.].

The answers to the 23 questions were measured on a five-point Likert-type scale where five was coded as the highest subjective perception and the one the lowest. After the data was gathered, the validated 23 items of the composite variable *learning effectiveness* were subjected to a Cronbach's Alpha reliability analysis for internal consistency. The statistical analysis gave a very high alpha coefficient (a=0.93) which indicated that the scale measuring effectiveness was highly reliable.

The open-ended section of the post-questionnaire concerned issues about students' likes and dislikes about the enriched classroom model, the deficiencies of the model and the Web-OL system in particular, and sugges-

Actor	Roles
Learner	◆ Navigates freely within the learning resources
	◆ Explores information resources
	◆ Asks questions
	◆ Collaborates with other classmates in team projects
	◆ Seeks feedback· Interacts with other learners either face-to-face or via e-mail
Instructor/tutor	◆ Organises content into learning resources
	◆ Gives lectures
	◆ Brings up discussion topics
	◆ Provides corrective feedback (either face-to-face or computer mediated for example via email)
	◆ Advises and tutors students
	◆ Assess the students
System Administrator – Course manager	◆ Creates and manages project teams
	◆ Displays and updates information about the course
	◆ Administrates the actors network

Figure 2: Actors and their roles

tions for improving the model. Through this part of the questionnaire it was also possible to examine the different students' perceptions of the course. The constant comparative method of analyzing qualitative data was used[23]. The focus of this analysis was to closely examine the substantial number of propositional statements that emerged from the data gathered. Our attention was directed both to the propositions which stood alone and to the propositions that formed salient relationships and patterns.

Major evaluation results

Comparing the average scores of the twelve questions from the pre-test and post-test questionnaires, we found that the students expected more of the enriched classroom model at the beginning of the course than was actually provided. The main reason was that this model presented an enormous innovation in the usual teaching and learning process for the students of the NTUA, to which they responded with initial enthusiasm. However, with relatively little experience in developing OL systems and never having conducted an experiment of this type before (either at the NTUA or anywhere else in the Greek higher education sector), mistakes were bound to happen. Early results were not necessarily the best possible from this model, and the difference between outcomes and expectations was not actually discouraging: it indicated that if improvements were made the model could meet the students' high expectations of this mode of learning[24].

The analysis of the qualitative data showed that:

• Students emphasised the flexibility provided by the enriched classroom in terms of time, pace and place of learning.
• Some of the advantages cited by students of the enriched classroom model were that it provided additional sources of learning and the possibility for further practice, and that it could provide a replacement for any conventional lectures which they missed.
• The enriched classroom model increased students' interest and curiosity about the subject matter.
• Students also emphasised that the Web-OL system was easy and intuitive to use.

The students commented on the following as adding value to the enriched classroom model:

• the extra course material, providing a good source for further practice and follow up;
• the complementary structure of the delivery modes (traditional and Open Learning);
• the possibility of accessing the online material from anywhere;
• the opportunity to prepare material in advance and to pinpoint major issues, problems and questions which could be brought in class for further elaboration and discussion.

There has been consistent evidence that, because of the potential for periodic courseware revision, extension and update, this model provides great flexibility in meeting educational needs and responding to a variety of learning styles. Interactivity was another important quality stressed by respondents. Respondents rated highly the need for the integration of computer mediated collaborative learning into the model, a dimension that was not considered in the first version. Another important attribute emphasised was the ability to allow students to interact with Internet sites on which they might find relevant learning material.

Elaborating on the problems identified by the students concerning the enriched model (and the Web-OL system in particular) we can mention that students most disliked:

• the inconsistency in the interface of the courseware;
• the low interactivity with the learning material (there were no simulations, self-assessment exercises, or other interactive features capable of inclusion in courseware);
• the poor communication system (Internet connections) in Greece which created difficulties in accessing the system from learning places outside the NTUA;
• the lack of adequate examples and case studies;
• the lack of computer mediated collaborative learning possibilities;
• online courseware which looked like a book in an electronic format.

Courseware should have involved high interactivity and challenged learners with simulations and referenced material. It should not have required them to simply absorb the material[25].

Lessons learned

The overall effectiveness of the enriched classroom model reached only a moderate level in its first version. When compared with the traditional mode of teaching, opinion tends to be slightly more in favour of the conventional, classroom-based mode. This is explained largely by the attachment of students to more human-centred modes of instruction and secondarily by problems related to the administration, design and development of the Web-OL system. Students were very strongly in favour of the use of the Web-OL system as a complementary delivery vehicle to the conventional one.

Taking into consideration the results from the quantitative and qualitative analysis of students' feedback, SEL staff proceeded to revise the Web-OL system. There were a number of significant changes and additions made to the system. The new version of the courseware consists of several additional parts such as the course description, a study chart, slideware, a sample examination paper with solutions, two more case studies, and more elaborated text, examples, and questions. Great care was taken to create a consistent, user friendly interface with a structure that is easy to understand and use.

A Web discussion forum (an asynchronous computer conferencing system based on the HyperNews software) was developed to allow the actors of the learning process to exchange information and opinions about the course. It is hoped that this will increase the level of computer mediated human interaction.

An *add annotation* function was implemented. This gives the students the opportunity to add personal notes on the pages of the online course material. The annotations will be either private or public. This function will be

equivalent to writing in the margin of a book.

The online courseware was enriched with advanced, up-to-date topics on software engineering. Having identified sources on the WWW which hosted good quality learning material on software engineering, the SEL staff arranged clearance from the authors to create links to their material from the courseware.

In conclusion, the great majority of students found that the enriched classroom model, despite several identified problems, positively affected their study patterns. They appreciated the independence of self-paced learning and information processing which this delivery mode provided. A second evaluation round will show if the revisions made to the courseware and the new functionalities added to the system are on the right track, and whether additional features are still needed. The first evaluation round showed that the experiment in using OL techniques based on the new technologies to complement the traditional classroom-based mode of teaching was generally successful. However, a lot of further effort will be required to really engage students and to achieve a high level of learning effectiveness.

Acknowledgement

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