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# Teaching ICT courses to virtual classes by using e-learning environments that support collaborative work

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ABSTRACT: In this article, the authors describe the setting up, realisation and assessment of two teaching experiments, which involved the inclusion of collaborative work in the teaching process. The experiments have been delivered to virtual classes of students that have been formed by the use of Internet-based e-learning environments. The purpose of these experiments was twofold. First, it sought to investigate the extent to which a teaching method that includes collaborative work can be applied to virtual classes of students by using existing Internet-based e-learning technology; secondly it sought to assess the effect of the approach on students' learning processes.

## INTRODUCTION

Research evidence indicates that computer-supported collaborative learning (CSCL) is one of the most promising innovations for increasing the quality of education with the help of modern information and communication technologies (ICT) [1-5]. This pedagogical approach emphasises the importance of engaging students and teachers in coordinated efforts to obtain new knowledge and to solve problems together [6]. Several empirical studies offer evidence that collaborative technology, when implemented with active teacher support, increases interest and facilitates higher-level cognitive functions [7-11]. Examples of this include deeper understanding, problem solving ability, reflectivity and social interaction. Both social interaction and reflectivity require the capacity to discuss the effectiveness of the activities and actions undertaken. A teaching method that engages students and teachers in coordinated efforts to obtain knowledge and solve problems, ie promotes the idea of collaborating learning, would be one that presents to the class the goals of the lectures, receives feedback from the class on a level of understanding and involves students in collaborative project work.

It is believed that many people who teach ICT courses would be interested to know the feasibility and effectiveness of applying such a teaching approach to classes of students, spatially distributed to different sites within a university campus or different campuses in different countries by the use of Internet-based e-learning environments. Therefore, there is a need to develop, test and evaluate more instruction and content delivery paradigms of ICT courses that are based on this teaching approach and can be delivered to classes of the form explained above.

Computer networks and advanced programming techniques are basic courses in many second cycle studies of traditional students. An experiment on the teaching of selected topics of a computer network syllabus by a number of different instructors to students located in different countries has been conducted as part of this work. The participating members of this experiment were the University Carlos III of Madrid, Spain, the INSA of Lyon in France, the University of Reading in England, UK, and *Aristotle* University of Thessaloniki in Greece.

Also, another experiment was carried out concerning the teaching of a complete course on programming in high-level languages to a virtual class with students located at two different sites within the same campus. This second experiment took place entirely in Thessaloniki.

In this article, the teaching approach, the course content and the environment selected for its delivery are briefly described. The experience gained and the conclusions drawn from these experiments are also presented.

## INSTRUCTIONS AND CONTENT DELIVERY APPROACH

The teaching methods involved in this experiment incorporated the following actions.

- Lectures on the concepts and theoretical aspects of each topic were presented by the use of overhead projector slides, scripts on a blackboard, graphics and animation;
- Questions from the tutor to students were posed and student feedback received by oral and written (e-mail) means;
- Solutions to sample exercises were demonstrated to students;
- Students in the virtual class were allocated to breakout groups and a project assigned to each breakout group;
- The solutions given for each project were discussed with the instructor;

- Students were requested to complete questionnaires that gave their assessment of the course content, the method of the content delivery and whether learning, in general, was improved;
- Instructors were required to evaluate the level of conceptualisation, problem solving and reflectivity skills achieved by providing appropriate examination tests to students.

As these functions should be used in a virtual class of students dispersed in different locations, an electronic learning environment should be utilised to implement the actions of the teaching method. The selected environment was the *LearnLinc*, which is a real-time environment that enables the delivery of courseware via the Internet [12]. It contains a palette of tools among which are tools that implement the required functions of the considered instruction and content delivery approach. These key tools are as follows:

- *Two-way audio conferencing*: This tool allows the instructor to talk with a student of his/her class, as if they were on the telephone and lets everyone else in the class hear this conversation as well.
- *Text chat communication*: This messaging tool permits anyone in class to write a message that is immediately visible on everyone's screen in the class.
- *Whiteboard*: This collaboration tool allows students and instructors to share simple drawings, text, imported pictures and screen captures.
- *A multiple choice question and answer tool*: This allows the instructor to ask a series of multiple choice questions and see the class responses instantly.
- *Instant feedback from class*: This polling application can be used by an instructor to solicit feedback from the students during the class. He/she may ask a question verbally or in text chat and have students respond using an answer set. The answer set can be of a True/False type of answer, A, B, C, D answer selection, agreement (Strongly agree, Agree, Disagree, Strongly disagree), assignment status (Still working, Almost finished, not much progress) and pace (Faster, Perfect, Slower, Please review).
- *A screen capture tool*: This tool lets the instructor capture any student's desktop during a class with the purpose of viewing a student's application or document and to troubleshoot a student's program.
- *Sharing applications with the class*: This tool enables the instructor to share his/her actions with the class or enable a student to share an application, ie the running of a program of his/her own, the execution of which can be watched by the rest of the class.
- *Creation of breakout groups*: A breakout group is a virtual group of students formed by students who are located at different sites of the virtual class and who can work collaboratively for a period of time. Students of any group can engage in everything that one could do in the main classroom, that is audio conferencing, sharing content, applications, whiteboard files and Web navigation, without the work of one group being monitored by another group, only by the instructor.

## CONTENTS OF THE COURSES

Based on the judgement of the instructors involved in each course, consensus on the content of each course was reached. The teaching of each module was assigned to an instructor on the basis of his/her expertise.

The duration of the first course was five weeks, with teaching of the subject at four hours per week. Three instructors taught the first course and its materials were split into the sequence of modules listed in Table 1.

Table 1: Sequence of modules on selected computer network topics.

| Topic | No. of Teaching Hours |
|---|---|
| Routing techniques | 4 |
| Network administration - part I | 4 |
| Network administration - part II | 4 |
| GRID computing | 4 |
| Web services | 4 |

The duration of the second course was eight weeks teaching with three hours per week. Four instructors taught the second course and its materials were split into the sequence of modules listed in Table 2.

Table 2: Sequence of modules on programming languages.

| Topic | No. of Teaching hours |
|---|---|
| Visual C++ | 8 |
| MatLab | 8 |
| Unix/Linux | 8 |
| Java | 8 |

## DELIVERY OF MATERIALS

The presentation of the material on computer networks included the following:

- A *PowerPoint* presentation;
- Yes/No and multiple choice questions that could be forwarded to students by using the questions feedback tool of the e-learning environment;
- Files with graphics, textual information and sample examples that could be displayed by utilising the whiteboard tool. This material was used by the instructor to explain ideas *on the fly* and to elaborate on concepts that students' feedback indicated they had a low understanding of.

A sample of a Yes/No question display on a student's screen is depicted in Figure 1. In this question, each student is asked to state which routing technique, out of three possible ones, has the lowest processing requirements per node.

Figure 2 indicates student feedback to the instructor, as processed by the e-learning tool. The feedback consists of three horizontal bar graphs at the bottom of the display that show the number of students who have selected each one of the three possible answers.

### Project Work

Finally, project work was assigned to student breakout groups. In this project, each student was asked to provide a brief description of the network topologies that are appropriate for a bank to interconnect all its branches and

whether routing needs to be applied. The same questions were asked for interconnecting the video and audio departments of an institute that focuses on multimedia research and to interconnect army camps with their headquarters. A project leader was nominated in each group who was responsible to communicate with the instructor and with members of other groups.

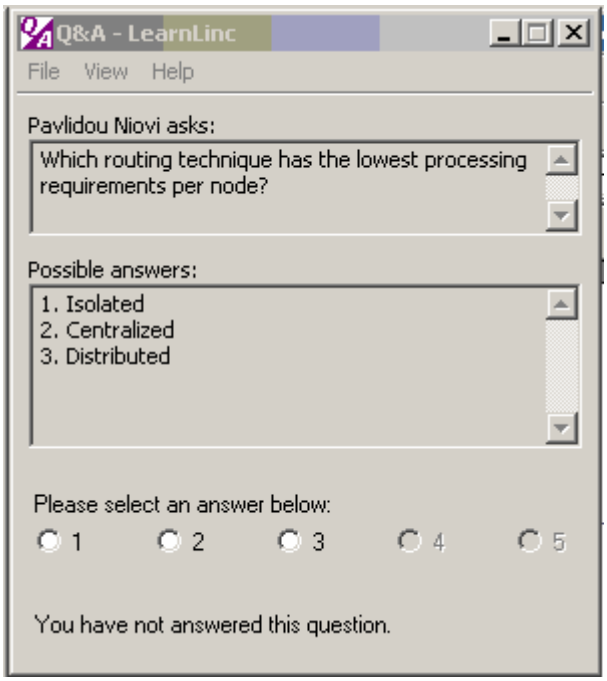


Figure 1: A sample of a Yes/No question display.

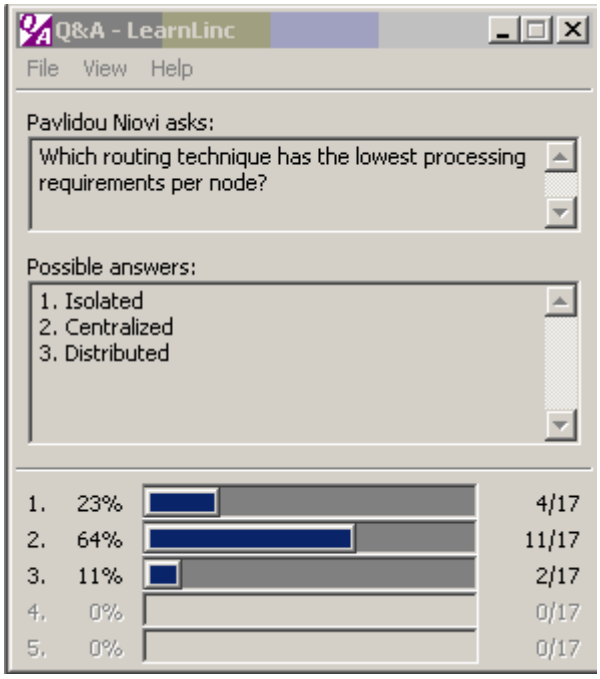


Figure 2: Results of students' answers.

## SET-UP OF THE EXPERIMENTS

After having defined the instructional approach and the course content, the following issues were addressed:

- Selecting the students;
- Scheduling the delivery of the course contents;
- Setting up and testing the electronic environment.

Eighteen students were selected to participate in the first course, and 61 to participate in the second course from those who were enrolled in the second cycle of studies of all the involved parties. In order to minimise the possibility of attributing the observed results to other variables that might have unavoidably influenced the learning process along with the teaching method and the material, the students involved in the experiment were selected to comprise a very consistent and uniform group so far as age, background and socio-cultural characteristics are concerned. Variables that might have influenced the learning process, apart from the teaching method, include the learner's cognitive and socio-cultural characteristics and his/her educational background [7]. So, the students were selected on the basis of equivalent performances on already examined courses, such as applied mathematics, programming, computer architecture and data structures, as well as on the basis of their socio-economic characteristics, such as having a family that resides in an urban area with similar income and parents' education levels.

Students of the second course were divided to four groups. At two different dates of the week, the same lecture was delivered simultaneously to a pair of groups, each group being placed in a different computer room from the other, thereby forming a virtual class.

The experimental teaching of the first course took place from 1-31 March. The teaching of the second course took place from the start of March until the end of May.

The e-learning environment was configured to allow an instructor who resided at one of the sites of the virtual class to control, via the use of appropriate tools, the display of his/her presentation materials and the materials that he/she wanted to show on the whiteboard, as well as to chat orally and textually with students at all sites, pose questions and request feedback from all students, including the forming of break-out groups. Since the operation of the environment used is based on the server/client model of communication, the server part of the software for the first course was loaded on a computer at the French site, whereas the client part of the software was loaded on all of the other computers located at the other sites. For the second course, a local server was utilised. Each lecture was recorded and, after its completion, was made available to anyone interested through the use of the appropriate tool in the environment.

## ASSESSMENT

The purpose of the assessment phase of the project was to rate experiences, identify required resources and recurring problems and to test the efficacy of the learning approaches. Of course, as with any educational approach, a basic assessment aim was also to evaluate whether the cognitive process is improved.

For a summative evaluation of both courses, students were asked to complete questionnaires and instructors asked to state their experiences, report activities and practices, and process test results. The test results were the answers of students' feedback to the instructor's questions asked during the normal flow of each course, and the examination tests conducted after the conclusion of each course. The results of their rating on the received answers to the questionnaire from students of both courses are shown in Table 3. The rating scale used was from 1 to 5. These numbers indicate to what extent the considered

properties had improved in comparison to traditional teaching and course delivery methods. For example, rating with a 3 would imply that no differences had been considered. A rating of 4 or 5 would indicate that the experimented method was considered advantageous, whereas a rating of 1 or 2 would suggest that the experimental method is considered to be worse.

In the questionnaire, the students were asked to rate the following properties of the learning process.

- The relevance of the subject matter to the aims of the module (*relation to goals* in Table 3);
- Whether the subject matter was interesting (*interest* in Table 3);
- How well they thought that they understood the course (*understanding* in Table 3);
- How satisfactory they found the e-learning technology to be (*environment* in Table 3).

Table 3: Percentage of student ratings for each property for the computer network course.

| Criterion | % Student Rating | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Relation to goals | 0 | 3.3 | 27.7 | 45.5 | 23.5 |
| Interest | 3.3 | 6.7 | 14.5 | 45.5 | 30 |
| Understanding | 0 | 14.5 | 65.5 | 13.5 | 6.5 |
| Environment | 0 | 1.5 | 30 | 44.5 | 24 |

The Q&A tests that were given to students consisted of Yes/No or multiple choice questions; these aimed to test the level of understanding achieved on critical concepts of the course. The results for each one of the posed questions are listed in Table 4.

Table 4: Percentages of the right/wrong answers for all the Q&A tests.

| Correct | Wrong |
|---|---|
| 70 | 30 |
| 78 | 22 |
| 66 | 34 |

The instructor's assessment of students' skills on the acquired problem solving ability, the achieved level of understanding of critical concepts and his/her reflection on the conceived solution is presented in Table 5. This assessment was based on the project work presented by the breakout teams.

Table 5: Assessment results of the project work.

| Skill | Rating | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Understanding | | | | x | x |
| Problem solving | | | x | x | |
| Reflectivity | | | x | | |

## CONCLUSIONS

Based on the results shown in the previous sections, the following conclusions have been drawn:

- The present state-of-the-art of e-learning environments support adequately a teaching model that is based on the conceptualisation and problem solving by collaborative work and dialogue;
- Apart from the fact that physical human contact between the student and the instructor is lost when an e-learning environment is utilised to teach a virtual class, its use seems to keep the interest of students high;
- There seems to be a difference of opinion between instructors and students as far as understanding is concerned. According to students, understanding is not highly rated, whereas the instructors considered that a high level of understanding had been achieved;
- Finally, instructors considered that very similar levels of problem solving and reflectivity abilities had been achieved with those of the traditional teaching methods.

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