Teaching I.C.T courses to virtual classes by the use of e-learning environments that support collaborative work.

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Abstract: This paper describes the setting up, realization and assessment of two teaching experiments which involved the inclusion of collaborative work in the teaching process and delivered to virtual classes of students, formed by the use of Internet-based e-learning environments. The first experiment concerned the delivery of a course on Computer Networks to students located in France, Spain, England and Greece and the other one on Programming in High Level Languages to students located in two different computer rooms within the same University Campus. The purpose of these experiments was twofold. First to investigate the extend to which a teaching method that includes collaborative work can be applied to virtual classes of students by existing Internet-based e-learning technology and secondly to assess the effect of the approach on the student's learning process. Students and instructors expressed a positive appreciation on the effectiveness of the approach and the ability to apply it to a virtual class.

1. 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 [2, 3, 4]. This pedagogical approach emphasises the importance of engaging students and teachers in coordinated efforts to obtain new knowledge and to solve problems together [1]. Several empirical studies offer evidence that collaborative technology, implemented with active teacher support increases interest and facilitates higher-level cognitive functions [6, 7, 8], such as deeper understanding, problem solving ability, reflectivety 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, that is promoting the idea of collaborating learning, would be the one that presents to the class the goals of the lectures, receives feedback from the class on the level of understanding and involves the students in collaborative project work.

We believe that many people who teach ICT courses would be interested to know the feasibility and the effectiveness of applying such a teaching approach to virtual classes, spatially distributed to different sites within a university campus or different campuses at different countries by the use of Internet-based e-learning environments. Therefore, there is a need to develop, test and evaluate instruction and content delivery paradigms of ICT courses which are based on this teaching approach and can be delivered to the virtual 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 the Computer Network syllabus by a number of different instructors for the level of the second cycle of studies to a virtual class with students located at different countries has been conducted as part of this work 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. The participating members of the first experiment were the University Carlos III of Madrid, INSA of Lyon in France the University of Reading in UK and the Aristotle University of Thessaloniki in Greece. The second experiment took place entirely in Thessaloniki.

In what follows, the teaching approach, the course content and the environment selected for its delivery are briefly described. Then, the experience gained and the conclusions drawn from these experiments are presented.

2. INSTRUCTION AND CONTENT DELIVERY APPROACH

In more detail, the teaching method involved the following actions.

1. For each topic of the course the learning goals are established and made known to the students

2. Lectures on the concepts and theoretical aspects of each topic are presented by the use of either overhead projector slides, scripts on a blackboard, graphics and animation.
3. Questions from the tutor to the students are posed and student feedback is received by oral and written (e-mail) means, during the presentation of the theoretical aspects of the topic, with the purpose of identifying misconceptions
4. The solution of example exercises is demonstrated to the students
5. Students of the virtual class are allocated to breakout groups and a project is assigned to each breakout group.
6. Solutions given for each project are discussed with the instructor.
7. Students are requested to assess the course content, the method of the content delivery and whether learning in general is improved by filling questionnaires.
8. Instructors are required to evaluate the level of conceptualization, problem solving and reflectivity skills achieved by providing appropriate examination tests to the students.

As these functions should be used in a virtual class of students dispersed in different locations, an electronic learning environment should be used to implement the actions of the teaching method. The selected environment was the LearnLinc [9], a real-time environment that enables the delivery of e-learning courseware via the Internet. It contains a palette of tools among which there are tools which seem to implement the required functions of the considered instruction and content delivery approach. These tools are:

1. Two-way audio conferencing. This tool allows the instructor to talk with a student of his class, as if they were on the telephone and everyone else in the class to hear this conversation.
2. Text Chat communication, that is a messaging tool that anyone in the class can use to write a message immediately visible on everyone's screen in the class.
3. Whiteboard, a collaboration tool that students and instructor can use to share simple drawings, text, imported pictures and screen captures.
4. A multiple choice question and answer tool, allowing the instructor to ask a series of multiple choice questions and see the class responses instantly.
5. Getting instant feedback from the class, that is a polling application that the instructor can use to solicit feedback from the students during the class. He may ask a question verbally or in text chat and have students respond using an answer set. The answer set can be 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).
6. A screen capture tool that the instructor can use to capture any student's desktop during a class with the purpose of viewing a student's application or document and troubleshoot a student's program.
7. Sharing applications with the class, that is the instructor can share his actions with the class or enable a student to share an application, i.e. running a program of his own, the execution of which can be watched by the rest of the class.
8. Creating Breakout groups. A breakout group is a virtual group of students formed by students located at the different sites of the virtual class who can

work collaboratively for a period of time. The students of any group can do 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 but only by the instructor.

3. CONTENTS OF THE COURSES

Based on the judgement of the instructors involved in each course, a consensus on the content of each course was reached. The duration of the first course was 5 weeks, teaching on the subject 4 hours per week and the duration of the second one was 8 weeks teaching on the subject 3 hours per week. The first course was taught by three instructors and its material was split to the sequence of modules listed in Table I. The second course was taught by four instructors and its material was split to the sequence of modules listed in Table II. The teaching of each module was assigned to an instructor on the basis of his expertise.

Table I : Sequence of modules on selected Computer Network topics

Topic	**No of Teaching hours**
Routing techniques for contemporary networks	4
Network administration-part I	4
Network administration-part II	4
GRID Computing	4
Web services and HTTP protocol	4

Table II: Sequence of modules on Programming languages

Topic	**No of Teaching hours**
VISUAL C++	8
MATLAB	8
UNIX/LINUX	8
JAVA	8

4. MATERIAL DELIVERY

The presentation of the material on Computer Networks included:

- a Powerpoint presentation. A sample of the presentation is depicted in Figure 1

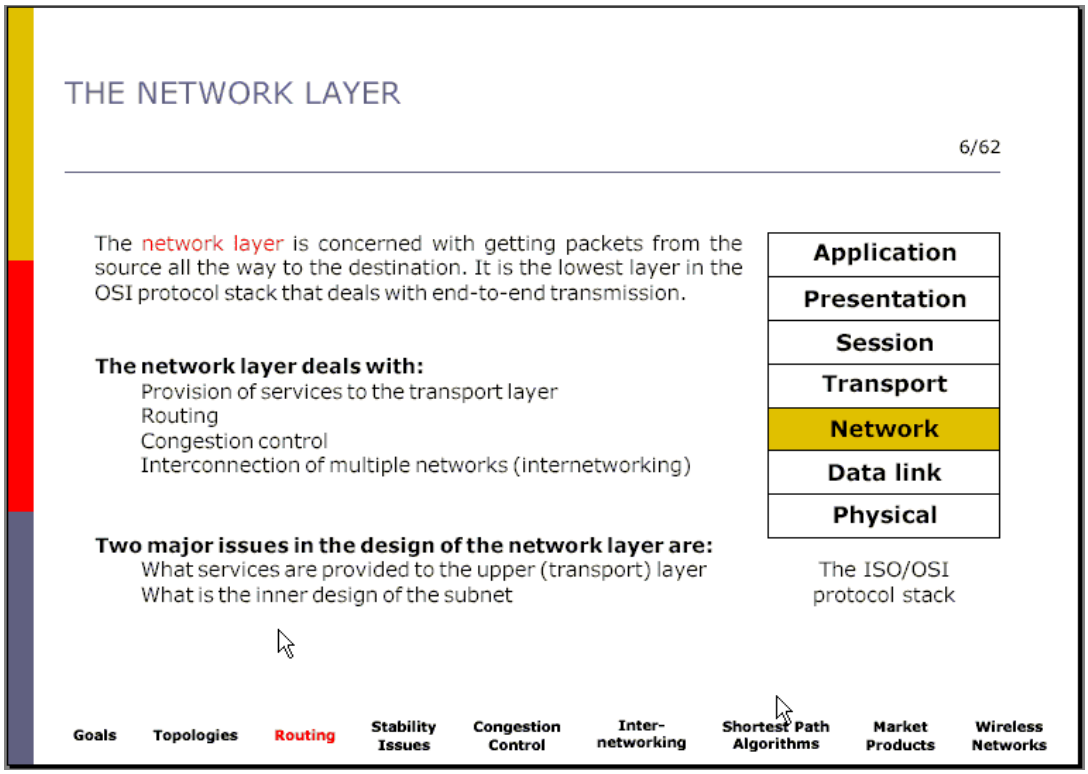

Figure 1: A sample of the slide presentation of the teaching material for the Computer Network course

In this slide the functions performed by the Network layer of the seven layers OSI standard are explained.

- YES/NO and Multiple Choice Questions for selected concepts in each module that can be forwarded to the students by the use of the questions feedback tool of the e-learning environment.
- Files with graphics, textual information and sample examples that can be displayed by the use of the whiteboard tool. This material is used by the instructor to explain on the fly and in a different way concepts that students feedback indicates a low understanding of them.

A sample of a YES/NO question display on the student's screen is depicted in Figure 2. In this question each student is asked to state which routing technique, out of three possible ones, has the lowest processing requirements per node, whereas in Figure 3 the student feedback to the instructor, as this is processed by the e-learning tool, is illustrated. The feedback consists of three horizontal bar graphs at the bottom of the display which show the number of students who have selected each one of the three possible answers.

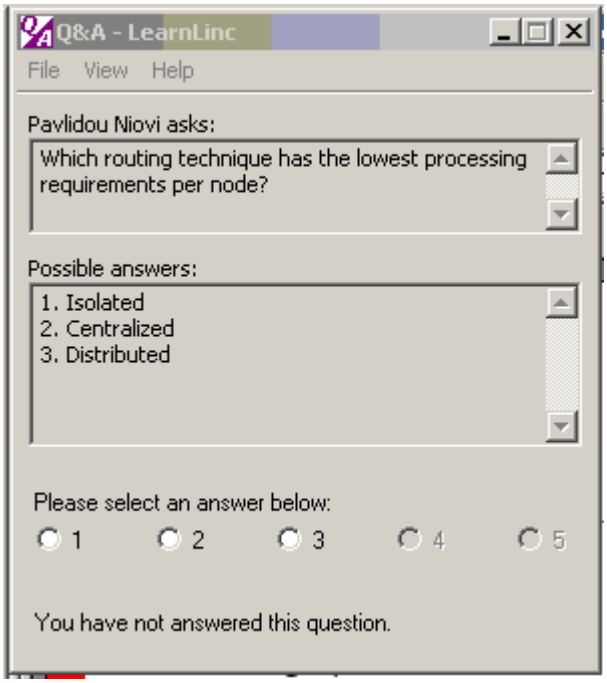

Figure 2: A sample of a YES/NO question display

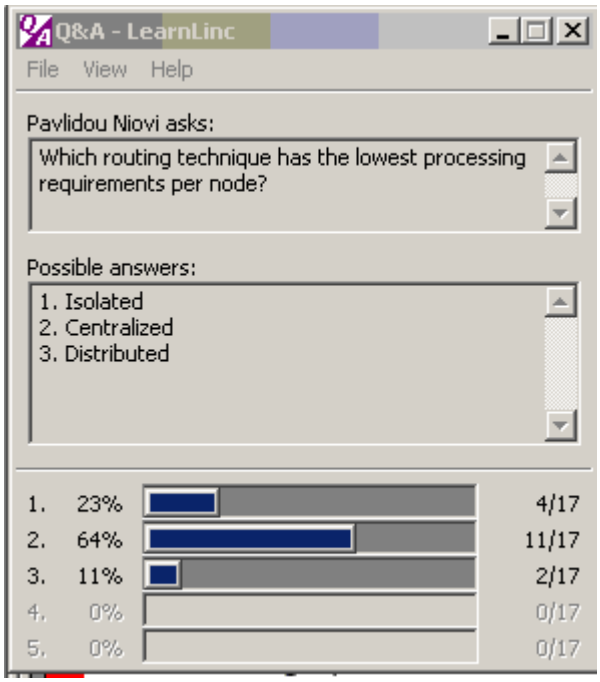

Figure 3: Results of the processed answers of the students to the instructor.

Finally project work assigned to student breakout groups had the form shown in Figure 4 for the Network course and the form shown in Figure 5 for the programming course. In this project the student is 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 are asked for interconnecting the video and audio departments of an institute focusing on multimedia research and

for interconnecting army camps with the headquarters. A project leader was nominated in each group who was responsible to talk with the instructor and if he wishes to, with members of other groups.

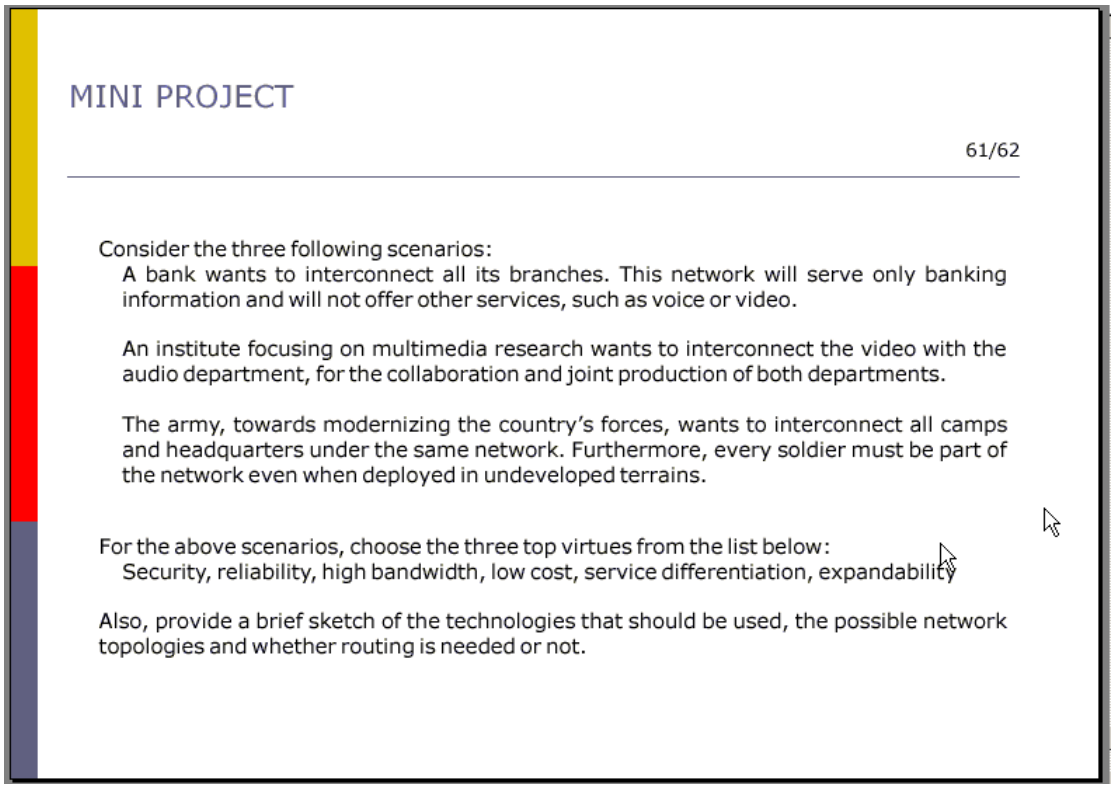

Figure 4: Project work assigned to a student group of the Computer Network course

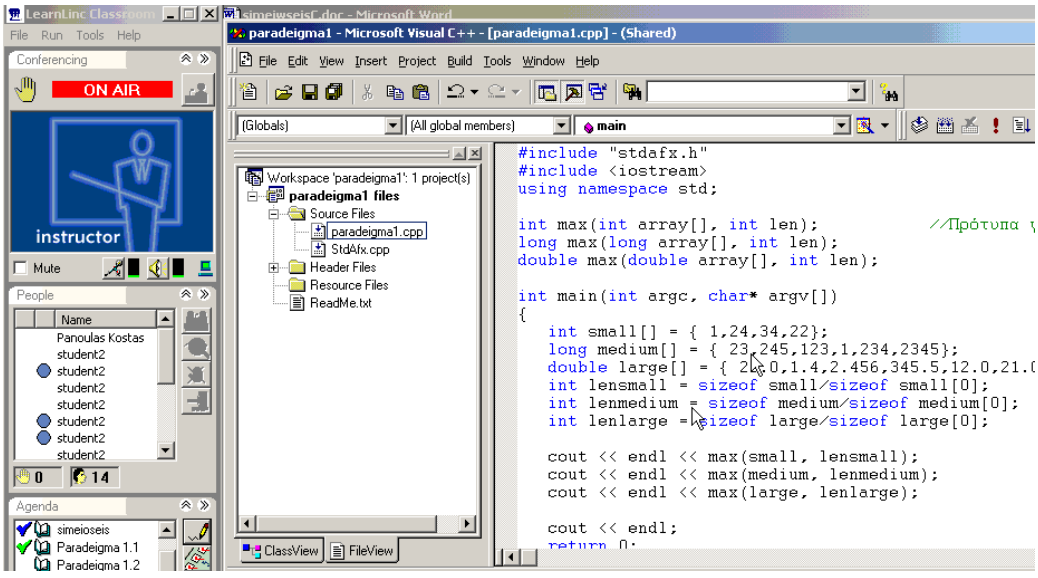

Figure 5: Project work assigned to a student group of the Programming course

5. SET-UP OF THE EXPERIMENTS

After having defined the instruction approach and the course content, the following issues are addressed:

- selecting the students,
- scheduling the delivery of the course contents,
- setting up and testing the electronic environment.

18 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 minimize the possibility of attributing the observed results to other variables which unavoidably influence the learning process along with the teaching method and the material, the students of the experiment were selected to comprise a very consistent and uniform group as far age, background and socio-cultural characteristics are concerned. Variables that may influence the learning process [6] apart from the teaching method, are such as the learners cognitive and socio-cultural characteristics and his or her educational background. 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, and on the basis of their socio-economic characteristics such as having a family that resides in an urban area with similar income and level of parents education. The 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 students group, each group being placed in a different computer room from the other forming in this way a virtual class.

The experimental teaching of the first course took place from 1-31st of March. The agreed schedule of the course is shown in Table III.

Table III: Schedule of the Computer network course

Date	**Time (CET)***	**Subject**	**Teacher**	**Institution**
Wenesday 5th March 2003	9:00 - 13:00	Routing Techniques for Contemporary Networks	Niovi PAVLIDOU and Gerasimos DIMITRIADIS	Aristotle University, Thessaloniki, Greece
Wenesday 19th March 2003	9:00 - 13:00	Network Administration - part I	Jean-Marc PIERSON	INSA Lyon, Lyon, France
Wenesday 26th March 2003	9:00 - 13:00	Network Administration - part II	Cécile MEYER	INSA Lyon, Lyon, France
Wenesday 2 April 2003	9:00 - 13:00	GRID Computing	Vassil ALEXANDROV	University of Reading, Reading, United Kingdom
Wenesday 9 April 2003	9:00 - 13:00	Web services and HTTP Protocol	Ralf SEEPOLD and Natividad MARTINEZ MADRID	University Carlos III, Madrid, Spain

Teaching the second course was scheduled to take place from March the 1st until the end of May. The course schedule is shown in Table IV.

Table IV:Schedule of the Programming course

Date	No of sessions per group	Session duration (hours)	Topic
12/3-31/3	3	3, 3, 2	UNIX/LINUX
1/4-7/4	3	3, 3, 2	MATLAB
10/4-9/5	3	3, 3, 2	Visual C++
15/5-25/5	3	3, 3, 2	JAVA

The e–learning environment was configured to allow an instructor who is residing in one of the sites of the virtual class to control through the use of the appropriate tools the display of his presentation material and the material that he wants to show on the whiteboard, chat orally and textually with the students in all the sites, pose questions and request feedback from all the students and form break-out groups. Since the operation of the used environment 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 the other computers at the other sites. For the second course a local server was used. Each lecture was recorded and after its completion it was made available to anyone interested through the use of the appropriate tool of the environment.

6. ASSESSMENT

The assessment phase of the project was aiming at documenting the experiments that introduce new instruction and content delivery paradigms by the use of e-learning environments and are based on modern pedagogical approaches. Also, it was aiming to rate experiences, identify required resources and recurring problems and test the efficacy of the learning approaches. Of course, as in any educational approach, a basic assessment aim was also to evaluate whether as a cognitive process is improved.

The recordings of the course on Computer Networks and the records of student participation and activities comprise the proof of the actual development of the new instruction and delivery paradigm. These data are available and can be accessed at the following web-site address:

http://newton.ee.auth.gr/seminaria

Similarly, the same type of data concerning the delivery of the course on Advanced Programming are available at the same web-site.

For a summative evaluation of both courses, students were asked to complete questionnaires and instructors to state their experiences, report activities and practices and process test results. Test results are the answers of the student feedback to 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 each one of the received answers to the questionnaire from the students of the Computer Network course are shown in Table V. Similarly, the results of the second course are listed in Table VI. In the questionnaire the students were asked to rate how relevant was the subject matter to the aims of the module (relation to goals in Tables V and VI), whether the subject matter was interesting (interest goals in Tables V and VI), how well they think that they understood the course (understanding goals in Tables V and VI) and how satisfactory did they find the e-learning technology (environment goals in Tables V and VI).

Table V: Percentage of student ratings for each property for the Computer network course

Criterion	% of student rating				
	1	**2**	**3**	4	5
Rel. to goals	0	0	37.5	62.5	0
Interest	0	0	0	83.3	16.6
Understanding	0	0	87.5	12.5	0
Environment	0	0	37.5	62.5	0

Table VI: Percentage of student ratings for each property for the Programming course

Criterion	% of student rating				
	1	**2**	**3**	**4**	**5**
Rel. to goals	0	3.3	18	49.2	29.5
Interest	3.3	6.6	14.7	27.9	47.5
Understanding	3.3	24.6	42.6	22.9	6.6
Environment	0	1.6	22.9	47.5	27.9

The Q&A tests that were given to the students consisted of Yes/No or multiple choice questions aiming 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 VII for the computer network course and in Table VIII for the programming course.

TableVII: Percentages of the right/wrong answers for all the Q&A tests for the Computer Networks course

Correct	Wrong
64	26
94	6
95	5

TableVIII: Percentages of the right/wrong answers for all the Q&A tests for the Programming course

Correct	Wrong
75	25
62	37
37	62

The instructor's assessment of the student skills on the acquired problem solving ability, the achieved level of understanding critical concepts and his or reflection on the conceived solution is presented in Table IX and X respectively for the two courses. This assessment was based on the project work presented by the break-out teams.

Table IX: Assessment results of the project work on Computer networks

Skill	***Level of skill***				
	1	**2**	**3**	**4**	**5**
Understanding				x	
Problem Solving				x	
Reflectivety			x		

Table X: Assessment results of the project work on Programming

Skill	***Level of skill***				
	1	**2**	**3**	**4**	**5**
Understanding					x
Problem Solving			x		
Reflectivety			x		

Experience gained from the instructors involved in the teaching of these two courses and their point of view can be summarized in the following comments:

- Working in breakout groups over an e-learning environment requires some prior training and inclusion of a function that would provide to the instructor an all times ability to follow-up the discussions and the on going work that takes place in each group.
- Network congestion is a problem that disrupts normal flow of work in the class and sometimes makes continuation of the lecture impossible.

- Working over an e-learning environment seems to increase student concentration and attendance but loss of the immediate human contact of the students with the instructor and among them restrains the students from being more active and interrogative.
- Introducing courses that require human resources and facilities not easily available to an institution becomes feasible by the use of e-learning environments.

7. CONCLUSIONS

It is the feeling of the instructors, supported by the just presented assessment figures, that:

- The present state-of-the-art e-learning environments support adequately a teaching model which is based on the conceptualization, problem solving by collaborative work and dialogue.

- Apart from the fact that the physical human contact between the student and the instructor is lost when an e-learning environment is used for teaching a virtual class, its use does not make any harm on the learning process

- On the contrary, teaching over an Internet-based e-learning environment might be considered to influence positively the learning process because of the observed increase of student concentration and attention

- However, an Internet-based e-learning environment does not offer the reliability and the stability of a conventional class environment for teaching. Network congestion, computer break downs and inadequate training of instructors and students in the use of the e-learning environment tools and commands may lead to loss of valuable time during a teaching session and sometimes disrupt or cancel the entire session.

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