SYNCHRONOUS AND ASYNCHRONOUS TELETEACHING: COMPARISON OF TWO EXPERIENCES

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Abstract. In this paper, two different types of teleteaching are compared: synchronous and asynchronous. The synchronous process is understood as a teaching activity in which the lecturer is directly connected with the students by video conference and whiteboard tools such as the MBONE tools through the Internet. Communication between lecturer and students takes place in real time. Asynchronous teleteaching is closely related to the well-known expression distance learning. The students retrieve data and tasks from information servers. The lecturer is not directly connected to the students and his or her replies to the questions are not given in real time. Beginning with a description of the two teaching scenarios, the differences between these two ways of teaching are introduced. Differences related to the interaction between the lecturer and the students, the generation of teaching content, the technical equipment and financial aspects are shown and discussed. Personal experiences of lecturers with synchronous and asynchronous teleteaching and evaluation results of student questionnaires are presented and compared to classical teaching. The paper finishes with a conclusion and some recommendations for on-going tele-educational projects.

Keywords. asynchronous and synchronous teleteaching, multimedia, virtual teaching environment

INTRODUCTION

Teleteaching can be carried out in different ways: synchronously and asynchronously. The differences lie in the interaction between lecturer and students. Synchronous teleteaching provides immediate verbal and non-verbal communication between the actors, while asynchronous interaction is delayed. Asynchronous teleteaching is often called “distance learning”.

This paper reports on two projects funded in Germany and in Spain. The synchronous project was carried out at the University of Hannover and the asynchronous project was completed at the Polytechnic University of Valencia. In this paper we address the advantages and disadvantages of both teleteaching scenarios.

The structure of the paper is as follows. Section two presents both scenarios. Sections three and four describe the development of content, technical equipment, interaction between the actors, etc. The fifth section compares them in terms of the subjective opinions of lecturer and students, as well as costs and technical aspects, and presents some evaluation results compared with classical teaching. The paper finishes with conclusions and some recommendations for on-going tele-educational projects.

SCENARIO

In every teleteaching experience there are four elements that are always involved in the process:

- Lecturer: coaches the students while they are acquiring the knowledge.
- Network: the hardware support for the learning process. (ISDN, PTN, etc.).
- Students: the individuals who are building up their knowledge.
- Content: subject and concepts that are presented to the students.

The lecturer either provides the service on-line by means of knowledge servers, or he or she attends the students personally at certain discrete points during the period.

EXPERIENCES

In this section we present the work at the University of Hannover and afterwards we describe the work at the Polytechnic University of Valencia.

Synchronous Teleteaching

The experience is based on two courses with twenty and ten students, each lasting one semester, which is a total of 26 sessions of 90 minutes duration each.

During the first session of the course, the lecturer was present in the lecture theatre in order for lecturer and students to get to know each other. During the series of classes there were two other lectures with the lecturer present.

The lectures considered are not related very strongly to mathematical subjects. The tactics developed during the years to get across the information to the students include

- verbal presentations, supported by slides, with live discussions during the lectures on the subjects presented
- additional literature to be read by the students with discussions on the articles during the lectures
- exercises presented one week prior to the presentation of the solution in the lecture theatre
- three written tests per semester of 20 minutes duration in the style and with the degree of difficulty of the final examination

General Description of the Synchronous Process.

In the following we elaborate on the hardware, software and networks used. The set-up of the production room (lecturers' location) and the lecture theatre (students' location) will be illustrated.

Transmission Network

The production room and the lecture theatre are interconnected using the Internet. The lecture theatre accesses the net at a speed of 2Mbit/s in a shared mode with the others, while the production shares the local access of 34Mbit/s with the others. The transmission speed is not a critical restriction.

Presentation Tools

The presentation at both locations was supported by the set of MBONE tools. Those tools were developed by universities and can used in the Multicast as well as in the Unicast mode.

The Learning Process.

Multimedia-Lecture Theatre

The room can accommodate 22 students. Each table for two students is equipped with one microphone which students activate if they wish to make a contribution. Another microphone is used to transmit the background noise of the lecture theatre to the lecturer.

Three cameras are installed; two of them are remote controlled by the lecturer while the third films from the students' viewpoint.

The lecturer and the whiteboard are projected using two beamers.

The operation of the equipment and tools is controlled and supervised online by two technicians (one per location) during the session. The session is handled by three computers in a manually operated load-sharing mode, which provides some redundancy in case of failure during the lecture. One Sun WS and one PC is virtually fully occupied with the operation of the moving picture of the lecture theatre, even with the support of a video capture board. The third computer (PC 1, Pentium II, Linux) presents the PowerPoint slides via beamer and controls cameras 1 and 2.

An important element for the success of the classes is the audio equipment. The correct audio levels in hi-fi quality need to be controlled by audio mixers for the signals in all directions. The signal delay of more than 150msec produced by the Internet and the digital signal processing of the audio and video signal requires the application of an echo canceller.

Production location (lecturer)

The lecturer's desk has a keyboard, a mouse and a telephone on it. The mouse operates the whiteboard. The audio signal of the lecturer is picked up by a wireless microphone. The screen with the windows of the whiteboard, the remote lecture theatre, the control picture of the lecturer himself or herself and the remote control of the cameras in the lecture theatre is projected by a beamer onto the video wall in front of the lecturer. Between the video wall and the lecturer is the camera which films the lecturer. The lecturer is virtually looking into the lens of the camera when he or she concentrates on the window of the whiteboard. This set-up is comparable to the use of a video prompter as used by newsreaders in TV studios. It helps to produce the illusion in the lecture theatre that the lecturer is looking at each student individually.

The control of the whiteboard includes the pointer which can be used to attract the attention of the students. Another possibility on the whiteboard is to do drawings. Using the keyboard the lecturer is able to transfer text onto the whiteboard.

As in the lecture theatre, the equipment in the production location is supported by two computers, mainly for load sharing purposes.

Training material

The material which is used for the teleteaching sessions is identical to that used in lectures with the lecturer present. It is a set of slides containing the goals of the session, references, abbreviations, facts presented in the form of lines of text or drawings, explanations prepared using animated pictures.

The students receive the HTML- and PDF documents prior to the lecture as an aid to comprehension and to enable them to prepare any questions.

For the actual lecture, the slides are available at the computers in both locations, in the lecture theatre and in the production room. They are loaded into the individual whiteboard tools before the session using the Internet. During the session, both of the whiteboards and thus the presentation of the slides are synchronised by the computer at the production location. Hence the lecturer controls the presentation of the individual slides, very much like in a session with his or her personal presence. A small but important difference is the inability of the whiteboard tools to present animations.

Lecturer's view.

The intention of the lecturer was to apply methods of knowledge acquisition to the students which are similar to

his or her standard lectures when he or she is physically present. There are a number of obstacles to the interaction between lecturer and students which are probably very difficult to overcome. In a real life lecture theatre, it is also difficult to stimulate a free but task-oriented discussion between the lecturer and the students at the beginning of a course. It takes some hours to create mutual trust, to see that the purpose of this discussion is not to test the students but to gain the ability to use and process the information and facts which are presented. At the beginning, trust is stimulated using minor questions and brain teasers presented by the lecturer. Throughout the courses, social behaviour develops which promotes direct questions and reactions on the part of the students to the subjects presented.

In the real life scenario, the lecturer is trying to direct the attention of students to the facts by pointing to the prepared slides or using the blackboard for additional explanations. He or she supervises the degree of attention and understanding by scanning the activities of the students during the speech. When the time comes for the students to become active, the lecturer addresses them directly; this is clearly visible to them and to him or her using direct eye contact.

In the teleteaching scenario, the lecturer has to look into the lens of the camera if he or she wants to give the students at the far end the illusion that he or she is looking at them. There is no difference in explaining anything, but the body language of the lecturer is not especially inviting if he or she wants to draw his or her attention towards the students in order to start a discussion. Just the opposite happens. If the lecturer first tries to get an impression of the activities going on in the lecture theatre before he or she asks his or her questions, he or she first looks at the part of his or her screen which shows the window with the students. Hence he or she is no longer looking into the lens, so consequently the students realise that the lecturer is looking somewhere, but not at them. Whom is he or she now addressing when he puts his or her question down the line? Certainly not the students. Why should they answer if they are not addressed?

The second difficulty in this context is the resolution of the window showing the lecture theatre. Even if it had the resolution of a full motion video screen, it would be impossible to read the body language of 10 or 20 students at the same time, as can happen if the lecturer is present in the lecture theatre. The scanning mechanism the human eye and brain uses to get an overview of the group of students and the subsequent concentration on the individual cannot be adopted by the camera control via the Internet. Thus it is virtually impossible to read the reaction of the students parallel to the lecture. Consequently the discussion with the students cannot be guided as in the scenario with the lecturer personally present.

If the lecturer expects to get into a discussion and does not succeed, he or she may well be disappointed. His or her face will reveal this and the students will realise it, because he or she is presented larger than life with his or her "talking head". What can a student be expected to do if he or she realises that his or her lecturer is getting angry? This type of negative feedback needs to be prevented.

The question arises of why the experience with video conferences is totally different from that in the lecture-theatre scenario. Video conferences can be as efficient as personal negotiations. Small distributed teams can perform excellently if the gap between the team members is bridged by a video conference. The difference lies in the number of participants. The number of participants in a video conference with interaction is at most six to eight, with two cameras for half of that group. Thus it is possible to transmit enough details to read the body language at the other end on the video screen. With such information a real sequence of arguments can take place.

The discussion with the lecturer present described above is a set-up where the lecturer and the students form a single group for the period of the discussion. The lecturer is a member as well as each student. Going back to the teleteaching scenario, the distance, the delay in the communication channels, the limitations in the perception of the isolated lecturer force the establishment of two groups, the group of students and the group consisting of the lecturer only. Such a set-up certainly does not promote free discussion where the lecturer can assume the role of coach.

Students' view.

As in regular lectures, students at the teleteaching lectures were given a chance to express their opinion on the quality of a session. The score is between 0 (very poor) and 5 (excellent). From the responses of the students we calculate the mean and the variance. The variance tells us something about the unity of opinion within the group of students. We asked the students to tell us something about their expectations and how they received the lecture.

It is obvious that the students very strongly miss the presence of the lecturer and the interaction with him or her. This opinion is in line with the observation of the lecturer. This outcome is in line with the observation during the regular lectures with the lecturer being present in-between, and where there were no difficulties in discussions.

Technical issues such as the quality of audio and video need to be improved. As usual, the importance of a high quality audio channel is more important than the video channel. Synchronisation between the audio and video channel is mandatory.

Financial Issues.

It is argued that multimedia and networking will influence lecturing at universities strongly. To achieve this, we need either to produce a better learning effect with our students or we need to obtain the same result while saving money. Here we will concentrate on the financial issues and compare them to the scenario where the trainer is present with the students. The costs are as follows:

- investment in the lecture theatre and the production room costs 150 000.00 Euro, covering the computers, beamers, microphones and cameras as described above.
- The running cost for the transmission are 1 000.00 Euro per lecture, which is somewhat artificial because their has been no real competition in this market up to now.
- The higher cost for the staff operating the lecture is 500.00 Euro, a crucial item.

Conclusion.

The experience of two semesters of synchronous teleteaching is that it requires much more discipline and awareness from the lecturer compared to lectures where he or she is present and thus has full control over the lecture, and can step back into a position of a coach in discussions with the growing experience of the group. This discipline can not be replaced by technical equipment.

Asynchronous Teleteaching

Continuous training is one of the most important emerging applications in training and teaching. The Internet is one of best vehicles for continuous training. The production of teaching material, and facilitating access to this material by students over the Internet, is frequently reduced to converting text to HTML files only.

The poor quality of the material is often explained by the complexity of production. To offer enhanced quality teaching material it is necessary to automate the process. The process in itself must be analysed in detail in order to obtain good pedagogical results. This section shows not only an automated process for producing courses that is currently being used at the Polytechnic University of Valencia as part of the European Union ADAPT initiative (INTERFAD project), but also a general distance learning process frame, or as it is called in this paper an asynchronous tele-teaching model.

This automated process is based on the generation of teaching material using a tool developed at the Polytechnic University of Valencia called IFTA – InterFad Lecturer Assistant. This tool allows the correctly structured integration of various multimedia materials such as text, images, video, audio, URL´s, etc. It generates an intermediate database which contains the Minimum Knowledge Units (MKU´s) and the relationships between them. This database is used by another generic tool that generates the web application for each course.

The pilot experience presented in this paper consisted in the provision of two series of distance learning courses. The first series started on June 1999 and finished in November 1999. It included eleven courses on different topics: Local Area Networks, SME´s Taxation, Quality Control and Automation. The second series started on December 1999 and will finish in April 2000. New courses have been added to the curricular up to a total of sixteen, covering new learning areas such as Enterprise Management and Strategy, Project Management and Information Systems.

As can be seen, the learning areas covered in this experience, and thus the kind of content of the courses, is very varied, allowing us to reach general conclusions regarding the methodology.

General Description of the Process (asynchronous).

With regard to the students, in the first series the number of students registered was around 400 and in the second around 600. The courses are aimed at postgraduate students who work for different companies, freelancers or civil servants. The number of students is thus high and the spectrum is wide, allowing us to reach some general conclusions.

The general process for learning material generation can be divided into two phases:

- Expert phase: production and revision of teaching materials
- Technical phase: generation of applications that can be remotely accessed by students

The first phase is related to the pedagogical aspects of courses. This phase is very important to ensure course quality. The second phase is related to the automatic generation of learning material using a lecturer tool developed for us called IFTA (InterFad Lecturer Assistant).

Between phases one and two an intermediate database is generated, called a ***concept database***. This database includes the course MKU (Minimum Knowledge Unit) objects and the presentational relationships between them.

In the technical phase, a web application with the course is automatically generated. A ***logical database*** is also generated that provides the applications. The structure of this database is logical rather than conceptual: it provides the applications and organises the web pages, or parts of web pages, with MKU objects ready for access and presentation.

The Learning Process: The Lecturer Assistant Tool And Web Application Generator.

- The lecturer assistant tool, like any software tool, has inputs and outputs. Inputs are course concepts produced by the lecturer and supported by various media (alphanumeric, images, video, audio) together with the timing and hierarchical relationships between them. Its output is a conceptual database containing the concepts in the form of MKU´s with the presentational relationships between them. In the tool the concept of MKU conceptual synchronisation is introduced. Three basic synchronisation relationships are defined:
- Sequentiality: one MKU must sequentially follow another.
- Simultaneity: two or more MKU´s should be presented simultaneously: for example, an alphanumeric concept and an image, or a video and audio, or text.
- Expansion: an MKU can be expanded into two or more concepts that clarify, or further refine, the idea.

The tool for generating web applications can be described by looking at its input and output:

- Input: conceptual database including MKU´s and the conceptual synchronisation relationships between them.
- Output: executable programs (HTML, CGI, JAVA, etc) and a logical database supplying the programs in use.

The tool is able to automatically generate a double output using the conceptual database and a catalogue of possible results depending on the structure of the conceptual database and the executable programs.

System Description.

The system for presenting asynchronous learning courses has three main elements:

- Database server.

- Web application server.
- Communication access.

The design fundamentals of the system are based on service and robustness:

An SQL Server was chosen as the database server because of its object-oriented structure which greatly facilitates the production of WWW applications. The usual safety features such as hard disk mirroring should be in place. The database server is accessed concurrently by the WWW application servers containing the course material.

The proposed system satisfies the requirement of remote access and a high degree of interconnection as well as a high degree of service.

Lecturer's view.

Opinion is divided in two aspects: material production and provision of courses.

With regard to the production of material, the use of a tool that automates the process is fundamental. Without a tool it would be hard to provide the material in terms of quality and time.

Nevertheless, the time needed to produce each chapter, equivalent to an hour of attending a class, is on average 15 hours. This time is high compared to the time needed to prepare a one-hour conventional lecture. However, it has to be considered that each chapter in distance learning must have a special pedagogical structure in order to replace the missing interaction between lecturer and student.

Conclusion: the production of training material is a long and costly process, despite the automated assistance that the authoring tool provides.

Regarding the provision of the distance learning course, the main advantage is the individualised and direct real-time control of the progress made by each student. The system permits the registration of all the accesses of the students to the course WWW server, and maintains a real-time data base with the advances and improvements of the students using an event register. The lecturer can obtain the state information of the student: the current chapter of study, the number of connections, the test results, the number of times the student has had to repeat each test before passing it, and much other additional information. Also, the students can ask the lecturers questions using e-mail.

So, as a conclusion to this section, the lecturers consider that the possibility of checking the progress made by students in real time is very positive, plus the fact that it takes place in an individualised manner. Without doubt, this is a great advantage of distance learning over conventional learning. However, it is obvious that the interaction lecturer-student that occurs in a class that is physically present does not exist in an asynchronous system.

Students View.

In the asynchronous tele-teaching experience at the Polytechnic University of Valencia, we gave a questionnaire to the students in order to obtain some feedback regarding their impressions of the course. There were forty questions, and we have selected those that are more meaningful for this paper and in general for the asynchronous tele-teaching model.

The students attending an asynchronous course prefer to connect in their free time, doing it at home rather than at work (60% vs. 30%). However, tele-training is a new experience for many of the students asked: more than 80% have never received one of these courses.

Half of the students prefer to read the information and work with the material of the course rather than interact and discuss with the lecturer. From the students that have contacted the asynchronous lecturer, it is possible to see that nearly all of them are satisfied with the attention they received from the lecturer.

The course taught at the UPV, as has been explained before, was made up of WWW material accessible to the students plus some additional material included in a book. Regarding the WWW material, which is the distance learning material proper, the students consider that the information is useful and the amount of information provided in this way is adequate to follow the course. They considered that the support information was enough to complete the course.

Regarding the WWW environment used by the students, they considered the presentation and structure of the course easy to use and intuitive and have more objections to the speed at which the results of the evaluations come from the system.

The satisfaction of the students concerning the replies given by the lecturer, is approximately equivalent in both courses (44% in tele-teaching and 46% in conventional teaching).

The students are more satisfied with the quality of the learning materials in the case of tele-teaching (80%) than in the case of conventional learning (46%), This aspect seems logical due to the greater dedication that the production of the learning materials for tele-training takes.

The satisfaction with regard to the general expectations of the students in the tele-learning process is higher (78%) than in the conventional learning process (56%).

Financial issues.

Most of the investment goes into the analysis and production (100 000.00 Euro) of the lecturer tool and the course provision database. Another important part of the budget goes to the pedagogical revision (40 000.00 Euro) of the material produced by the experts, and of course the cost of the development of the courses by the experts (100 000.00 Euro). These quantities depend on the number of courses generated and provided, in this experience a total of 16.

Also, it has to be emphasised that the cost of utilisation of the Polytechnic University of Valencia local area network has not been included in this discussion of the economics. This network has the server directly attached to it and the students access through Internet. Not included is the cost of the student Internet connection because it is paid for by the students.

Conclusions.

The results of the experience seem positive, taking into account the limitations of a kind of learning in which there is no interaction between the lecturer and the students. The satisfaction of the students after taking the course seems to

be very high, and the lecturers mainly value the advantage of individual study on the part of the students.

With regard to economic aspects, the cost of the investments for the development of the lecturer tool and the programming of the applications is initially very high, although obviously it will pay for itself with the development of new courses. On the other hand, each newly produced course has fixed costs dependent on the course, i.e. the production of the material (involving high costs although the lecturer tool is used) and the pedagogical revision, which is fundamental to ensuring the quality of the learning materials.

COMPARISON AND RESULTS

	Synchronous	Asynchronous	Classical
Interactivity	😐		
Investment		😐	
Running Cost			😐
Savings			😐
Quality of Materials	😐	😐	😐
Students' view			
Lecturer's view		😐	
Learning benefit	😐	😐	

Tab. Comparison of synchronous and asynchronous teleteaching with classical teaching

As shown above, the experience with asynchronous teleteaching is slightly better than with synchronous teleteaching. The latter competes directly with conventional lecturing, while the first is compared to individual non-guided studies, which usually takes place after leaving university, in the process of life-long learning.

Both methods require much more discipline in the preparation and the presentation of the material, due to the fact that the lecturer is not physically present and the impossibility of interaction during the lecture.

The high cost for the preparation of the material in the asynchronous case can be recovered if the lecture is repeated often enough. The cost for the synchronous lecture can be expected to drop, partly due to reductions in rates for communication links. A more critical aspect in this case is the additional factor of the supporting technicians.

It is expected by the authors that a combination of both methods will produce a remarkable improvement in the situation regarding cost and efficiency.

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