Project TeleTeaching Mannheim - Heidelberg

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Abstract: The technology needed for teleteaching is widely available today. Interest focuses on the use of multimedia technology and high-speed networks to disseminate course content and work and deepen understanding on the part of the students. The Universities of Mannheim and Heidelberg are engaged in a joint pilot project to develop and test new technologies for teleteaching in a digital network. High-capacity multimedia workstations and PCs are linked via ATM to enable access over the network to lectures, exercises and stored teaching materials. The departments of education and psychology of the two universities are scientifically advising and evaluating the project.

1 Introduction

Inauguration of the new course of study in Computer Engineering ("Technische Informatik") at the University of Mannheim gave the final nudge for instigating the joint teleteaching project with the University of Heidelberg. The required courses in physics are currently not available at the University of Mannheim and the establishment of a faculty of physics solely for this purpose was out of the question. Conversely, while the University of Heidelberg allows students to minor in Computer Science in a variety of fields, the number of courses in computer science available is insufficient. Mutual aid was thus an obvious alternative. Generally it can be said that the University of Heidelberg and the University of Mannheim are predestined for such a cooperative venture due to their geographic proximity and their complementary spectrum of courses.

The main goal of the teleteaching project between the universities of Mannheim and Heidelberg is the improvement in the number and type of courses available at either institution. On the one hand, a broader spectrum of teaching activities at both universities is envisioned, while on the other it is hoped that the use of multimedia teaching aids (animation, visualization of technical calculations, 3-D models, etc.) will enrich and intensify the transfer of knowledge. Teleteaching aims to supplement rather than to replace current methods of teaching and learning.

2 TeleTeaching Scenarios

Several teleteaching scenarios are under investigation within the course of the project. In all cases the latest multimedia technology is in use, with

transmission over an ATM high-speed network. The high bandwidth of ATM allows the integrated transmission of video, audio and data streams of high quality and in both directions. Thus the project also fosters development of further innovative applications for high-speed networks.

2.1 Scenario 1, Remote Lecture Room (RLR)

The initial pilot phase began with the installation of multimedia equipment in one auditorium respectively at the University of Mannheim and the University of Heidelberg. In each of the two auditoriums there is one camera focused on the instructor, and a second camera focused on the students. The instructor uses a multimedia workstation rather than an overhead projector. Its screen contents are projected by an RGB projector as a large image in the local auditorium. The transparencies used in the presentation are prepared for the computer. This enables the use of graphics and pixel images in color. Midterm planning includes the use of video clips, particularly animated scenes, the visualization of algorithms and processes, and 3-D models that can be controlled interactively. Later on, a second RGB projector will project the image of the audience in the remote auditorium on to a side or the rear wall of the local auditorium. Figure 1 depicts the Remote Lecture Room scenario.

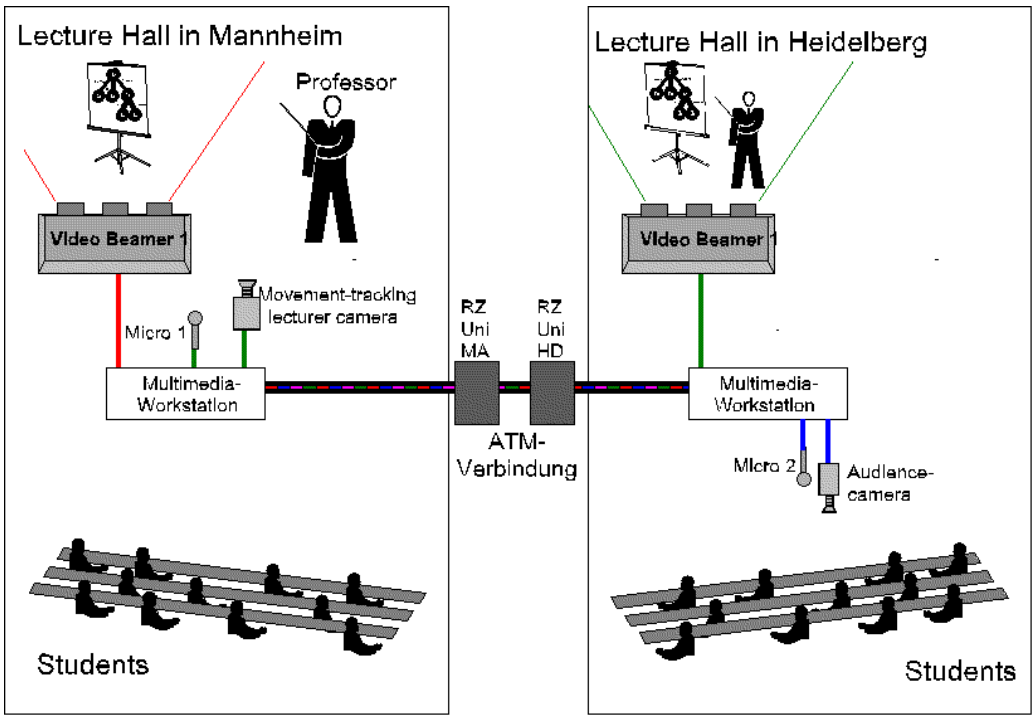

Figure 1: Remote Lecture Room (RLR) scenario

During a lecture, three data streams are activated and transmitted: the video and audio from the instructor's camera, and the "whiteboard image". At the same time, two channels will be activated on the remote end: the video and audio of the audience. While lecturing, the instructor is able to see the students at the remote site on the screen of the local workstation. Any questions they ask there are heard by everyone in the local auditorium. Students in both auditoriums are able to see the "whiteboard image" (better: digital lecturing board) as a large image. The same equipment (hardware and software) is used in the auditoriums in both universities, so that transmissions of courses can take place in either direction.

2.2 Scenario 2, Remote Interactive Seminar (RIS)

A small seminar room is equipped with a multimedia workstation and a high-speed network link. The transmission of the data streams is similar to that in the first scenario (RLR). Equipment costs are much lower, since it is much easier in small rooms to attain high-quality levels of image and sound. Advanced level seminars are offered each semester on an inter-university basis, whereby students will be able to engage in inter-site discussions. This scenario bears a strong resemblance to that of the traditional videoconference.

During the winter semester 1996/97 a teleseminar entitled "Digital Money" was conducted jointly by the universities of Mannheim, Karlsruhe and Freiburg in the RIS scenario. Each university was responsible for four lectures.

2.3 Scenario 3, Interactive Home Learning (IHL)

Currently in the planning stages is the Home Learning scenario, in which students can participate in lectures online from a PC via ISDN. Interactivity is available here as well.

The realization of multicast groups via ISDN poses a technical challenge. In order to efficiently support a greater number of participants, it is important that the network know the multicast group and support it with a protocol. Much work still has to be done to this end. Another challenge is the adjustment of the quality of audio and video to the various bandwidths. Hierarchical coding of video would be desirable, so that each participant can be served with the optimum bandwidth and quality of image. Unfortunately such hierarchical coding does not yet exist. And finally, new graphical user interfaces must be developed for the instructors. It is still unclear how to best present a large number of students at their home workplaces on the instructor's screen and how best to call on them, when they have a question or comment.

Figure 2 illustrates the tree online scenarios RLR, RIS and IHL.

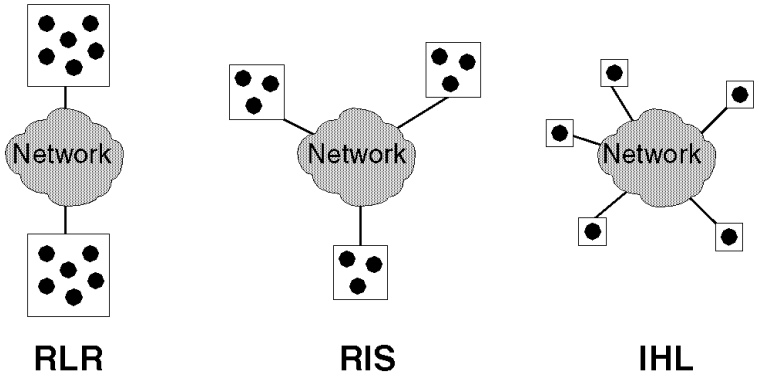

Figure 2: The three online scenarios

2.4 Scenario 4, Offline Distance Learning (ODL)

Making relatively minor extensions to the equipment enables the simple (analog) recording of lectures for later digitalization, compression and storage on a large disk server. A video server will be established that will have an index of video recordings suitable for digital remote retrieval. During preparation for exams, the student can dial up the video-on-demand service and call up the material components to be reviewed. In the ideal setting, almost every lecture will have been "revised" after the fact. Errors made during the lecture or long pauses will have been edited out of the video. Additional interactive learning materials will also be available. A number of tools for the efficient authoring of multimedia materials "on the fly" are currently being developed at the University of Freiburg.

The preparation, storage and network-wide transmission of multimedia learning materials is not very well understodd yet; many research issues are still open, for example the automatic indexing of digital videos, the optimal scheduling of videos on distributed servers, or real-time transmission protocols in packet-switched networks. (Bernhardt and Biersack (1994), Rangan and Vin (1993), Effelsberg et al. (1994))

3 Application Software

Application software used in the project is in the form of the MBONE tools, which are very popular in the Internet: sdr (Session Directory, LBL), vat (Visual Audio Tool, LBL), vic (Video Conferencing Tool, LBL and ICSI), and wb (Shared Whiteboard, LBL and ICSI). These are already in widespread use in the U.S.A. and an active user community sees to continual further development. By using Multicast-IP the communication with several end points can be carried out at the same time (Deering and Cheriton (1990))

We consider multicast support within the network to be an essential prerequisite for the scenarios Remote Interactive Seminar and Interactive Home Learning.

4 Educational Support and Evaluation

Educational support and evaluation is carried out by the Department of Education in Mannheim and Department of Psychology in Heidelberg. The primary goals are an on-going assessment of the learning success and the media-didactic advice of the educators.

Medial solutions to date, such as the exchange of videocassettes or traditional television transmissions, do not allow the "remote student" any influence on the instruction by means of questions or contributions to the discussion (Niegemann (1995)) The instructors lack feedback on the reception of their lecture and on any remaining questions students might have. Teleteaching can deliver a solution to such basic educational issues: Teaching activities are transmitted with the opportunity for instructors and students to interact. To date there is little first-hand experience in Europe with such a form of university education

An important function of the educational-psychological support and evaluation lies in the extensive formative and summative assessment of teleactivities and multimedia learning aids. Formative denotes the evaluation accompanying such measures for the purpose of optimization. A summative evaluation consists of the final evaluation of a measure with regard to the realization of its formulated goals. Evaluative studies in the course of the TeleTeaching Project are structured according to the evaluation model of Wittmann (Wittmann, 1990). This model permits a careful analysis of the efficacy of variables with a potential influence on the intervention measures. It connects research issues and goals with advance information on the users and frames of reference (predictors), questions as to study design and potential effects of measures.

5 Multimedial Teaching Materials

The accompanying development of multimedial teaching materials (video clips, animated scenes, simulation programs with interactivity, etc.) is essential; it is foreseen for all teleteaching activities between Mannheim and Heidelberg. Only in this manner can the potential for new technology be used optimally. Springer-Verlag Heidelberg brings important experience to bear.

Of particular interest are simulations that students can operate on their own. Volume models of the human cranium, for example, can be prepared for a lecture in anatomy. These can be rotated in three-dimensional space and dissected into their components, giving students a much more precise idea

of space than that offered by illustrations in an anatomy textbook. Or, supplementary to a physics lecture on harmony oscillations, for example, there would be a PC simulation model, by means of which students could alter such parameters as the spring constant, and the damping factor and observe the resultant effects. These two multimedia learning aids already exist today and they deliver an excellent idea of the potential borne by new media in the field of education (Springer Verlag URL: http://www.springer.de).

The creation of such teaching materials entails an immense effort; experts estimate that approximately 200 hours of preparation are required for one hour of lecture time, in addition to the fact that most instructors have not learned to deal with the new media. While the writing of a scientific paper or textbook is considered part of the standard repertoire of a scientist and is practiced during university studies and in the preparation of one's doctoral thesis, the planning and production of an instructional video, an interactive hypermedia document or interactive learning software represent new challenges. Teamwork affords a chance to streamline the individual effort involved: Several colleagues, who all hold similar lectures at different universities, can collaborate, each developing multimedia instructional and learning materials to cover a subsection of the entire topic. A second alternative is "authoring on the fly": Video, audio and "whiteboard" annotations are recorded while the lecture is in progress. The raw material gleaned with relatively little effort can be extended by written materials and deposited on a server for call-up.

6 Experience

During the summer semester 1996 a complete course on computer networks was transmitted regularly from Mannheim to Heidelberg in the Remote Lecture Room scenario. Brief descriptions of our initial experiences from both a technological and an educational-psychological stance, as well as from the standpoint of the instructor, follow.

6.1 Technology Experience

Definitely positive was the transmission of an electronic transparency image with the aid of the shared whiteboard wb. This posed no technical problem at all and the quality received by the students was good. Audio quality was also very good, aside from phase-wise disturbance. Audio coupled with whiteboard annotations is of primary importance in transmitting instructional content in the field of computer science, whereby video is more important with regard to raising the social presence. The video image of the instructor was transmitted in H.261 format at a frame rate of ca. 16-17 fps. Higher frame rates were not attainable because the workstation had to do the encoding and decoding of all streams in software. The end systems, rather than the bandwidth of the network, were the bottleneck.

In summary, first transmission of a complete lecture was considered to be quite successful with regard to technology despite the minor problems that occurred. Modifying the routing of the network link between Mannheim and Heidelberg, largely solved the audio dropouts by the end of the semester. The primary factor for the success of future activities of this type, however, lies in the possibility of reserving bandwidth on the network.

6.2 Educational and Psychological Evaluation

Figure 3 illustrates the evaluation program carried out during the semester. Data were gathered throughout one semester by means of a total of four written questionnaires, sample interviews and participatory observation both on-location and at the remote site. In addition, advance information about the participants (for example, courses similar in content that they had already completed, their motivational structure, etc.) and for later reference, information with regard to their reasons for dropping out, was gathered by means of electronic questionnaires installed on the WWW. Data were gathered on motivation, concentration, comprehension difficulties, rating of the lecture, acceptance of the remote situation, evaluation of technical aspects of the transmission, etc. As an additional, semi-experimental variation, the instructor changed location midterm for a period of four lectures (moving from Mannheim to Heidelberg). Thus both groups, who differed with regard to the potential variables of influence such as course of study, advance knowledge, motivation and relevance of the lecture contents for examinations, could be studied under both conditions (remote and on-location). The interview intervals were (1) at the beginning of the semester (predictors), (2) directly prior to instructor's change of location, (3) directly prior to instructor's change back to the original location, and (4) at the end of the semester.

At first sight, both groups already differed strongly at the outset. The students in Mannheim demonstrated more advanced knowledge and a motivational profile more strongly oriented to the examination in that subject. This is not surprising, as computer science, the category of the lecture transmitted, is a full course of study in Mannheim, whereas it is an elective only for students of mathematics or physics in Heidelberg.

Of the 139 students participating in Mannheim at the beginning of the semester, 80 remained at semester's end. The number of students decreased continually over the course of the semester, whereby a sharp drop can be observed at the time of the instructor's change of location to Heidelberg. On the Heidelberg end, 22 students were enrolled at the beginning of the semester, dropping to merely 5 by the end of the semester. Here, a drop of approximately 60% occurred in approximately the fourth week of lectures. Results to date from questionnaires (electronic and paper) and interviews permit the assumption that especially the minimal relevance of the lecture for students in Heidelberg with regard to their examinations is responsible for the drop in attendance. In favor of this interpretation is that fact that

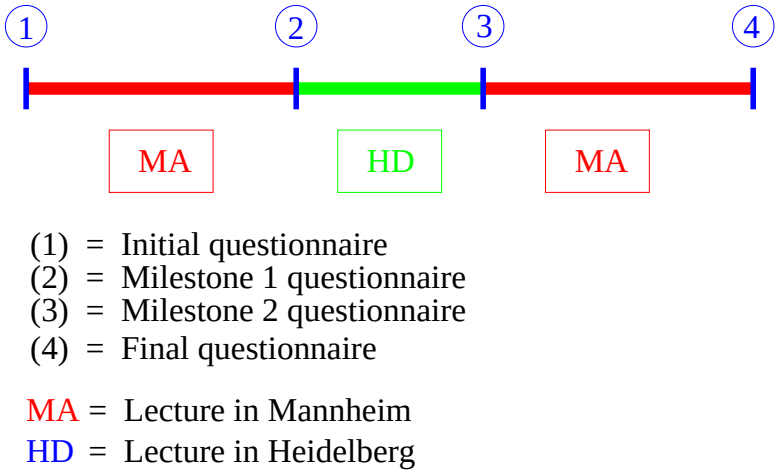

Figure 3: Educational Evaluation

neither was the teleteaching technology negatively rated, nor did the lecture fail to satisfy. Quite the opposite was true: data indicate that although the technical disturbances occurring at the beginning of the semester, among them particularly the audio transmission, were criticized, teleteaching as such was well appreciated on the remote end. Finally the lecture was rated all in all by both sides as good to very good.

The interactivity (questions put to the instructor, etc.) was minimal on both ends, which was to be expected in a "traditionally" structured lecture setting with a very large number of students. However, the students did not seem to exhibit much of a need for more interaction with the instructor. In comparing both groups, it is apparent that students at the remote site felt less free to ask questions, which was ascribed on the one hand to the technical barriers (questions via microphone after prior handraising), and on the other to their uncertainty as to "interfering" from Heidelberg in the course of the lecture in Mannheim.

6.3 Instructor's Experience

There is little experience on the part of instructors in Germany with teleteaching; use of the new technology is unfamiliar. Respectively interesting specific experiences can be described for the three media: audio, video and electronic whiteboard.

The *audio transmission* posed the fewest problems. On-location the usual auditorium neck-microphone was used. The quality of the audio was generally good. Unfamiliar was only the use of the student microphones for questions during the lecture: while in the local auditorium, questions during a purely local lecture can be put without the aid of a microphone since the

acoustics are good, in the remote auditorium the students had to make their way to the microphone or else had to be given a portable microphone. To have equipped all seats in both auditoriums with individual microphones would have been prohibitively expensive.

Use of the *video equipment* was made significantly easier by having a student aide to operate the camera in the local auditorium. Our experience shows that the instructor cannot carry out this job, since it distracts too much from the main didactic task.

In lectures on computer science, annotations on the whiteboard are an important means of communication (pointing, writing, developing small drawings interactively, etc.). Thus the freedom of movement on the part of the instructor is considerably restricted. In other fields, where the freedom to gesticulate and facial expression of the instructor are important, a camera operator on-location could be very important. We plan trial of *object-tracking* software in connection with a tilt/swivel mount for the camera; by this technique an instructor could automatically always be kept in the scene.

If the instructor has experience with computers, handling the *whiteboard* ought not to be too difficult. The graphical user interface is easy to learn. Particularly annotation (pointing, marking, framing, writing) is easy to learn and was put rapidly into effective use. Construction of small graphics with the mouse was also easy. However, the ability to enter and edit mathematical formulae was sorely missed.

The educational advisors in the auditorium ascertained that the concentration on the part of the students always rose noticeably when something on the whiteboard was developed "live". For this reason we recommend the increased use of *half-ready transparencies*, which can then be completed during the lecture, perhaps even in interaction with the students. A prerequisite is the advance preparation and availability to students of the (ready and half-ready) transparencies, which was the case in our project (via WWW).

In disciplines which use neither transparencies nor a blackboard, but primarily declamation, little difficulty should be encountered in teleteaching. A slight but manageable adjustment must be made by an instructor who is used to working with overhead transparencies (these can be loaded into the whiteboard as PostScript files), but who has little experience with computers. We expect acceptance problems above all in those areas in which the blackboard classically plays a role in the scientific culture, such as in mathematics, or in areas in which the PC or workstation are even today unknown entities.

7 Conclusion

Initial experiences within the project are very encouraging. The number of surprising and interesting results encountered in such a short time is amazing. Once the early problems with the audio and whiteboard had been solved, the technology posed few problems. The quality of video, however,

continues to be a problem.

The educational advice and evaluation proved extraordinarily helpful and interesting. These constitute a central component of the project. Within the next few months we will be instituting a third scenario (Home Learning) and gathering new experiences. At the same time the development of active elements (animated scenes, video clips, etc.) continues.

For up-to-date information please refer to URL http://www.informatik.uni-mannheim.de/informatik/pi4/projects/teleTeaching/

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