

eLearning in Civil Engineering: The experience applied to a lecture course in Structural Concrete

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Abstract:

For the first time, the lecture course in Structural Concrete at IBB has been supported by a web-based course management system. The possibilities of eLearning give students a deeper insight into the more complex structures encountered in civil engineering. A number of animations and simulations have been created during the project, which have been shown to be particularly helpful in explaining and visualizing these complex concrete structures. In this paper we give an overview of the lecture course, the didactical concepts and the first experiences. The results of an evaluation of the web-based tuition, performed in parallel with the lecture course, are discussed and subjective impressions highlighted. Finally, the potential of applying this on a broader scale and the advantages and problems of such wider application of the technology, are proposed.

1. Introduction

“The World Wide Web offers educators a new medium to deliver teaching and learning material – one which can bring new and exciting ways of learning, and an alternative to traditional teaching techniques” (Robert Allen, (1998)). – Such opinions are often expressed in today’s press and industry journals. Is one-to-one education a thing of the past? Does the internet offer a new way of teaching? Must universities strike a new path of teaching approaches and create more opportunities for interaction and reflection with the trainers and tutors, leading to better student understanding? Could eLearning be a partial supplement of the classroom teaching? In order to attempt to find answers for these questions, a study of internet-based learning has been instigated at the IBB in Graz University of Technology. A course management system containing the entire content of one of the Civil Engineering undergraduate courses (i.e. notes, handouts and supplementary animations etc.) was set up and used from November 2001 to February 2002. The results of this study of the virtual lecture course are the main topic of this paper. After giving a short review of the lecture course, the paper continues with a description of the didactical concept used in the web tutorials. The experiences of the eLearning technique are then described in some detail, leading to proposals for the future of the approach, in particular which tools are necessary and appropriate for a wider use of the system, and what are the potential pitfalls to avoid?

One of the real strengths of the Web environment is the scope for interactivity. Interactivity helps to motivate learners by providing information in an easier way, for example through the use of animations and simulations of complex concepts (Holzinger, (2002)). An anonymous evaluation of the students who had used the new web-based system was made, allowing important factual issues and goals for the future to be pointed out. The result of this anonymous questioning shows a surprisingly high acceptance of the system by the students concerned. The students were particularly appreciative that the web based training opens a new door towards the flexibility of learning. The basic message was that the use of a management course-system leads to a better conversation between lecturers and students and to an increasing understanding of the subject matter, in this case non-linear material concrete. Finally we take a closer look into the future and try to answer some main issues for ensuring successful eLearning lessons. A set of remaining issues and points for further discussion by the industry are

presented, which we hope, combined with the preliminary experiences described, will allow this paper to contribute to a “better” eLearning future.

2. The lecture – Structural Concrete

In combination with the multimedia project of the Graz University of Technology (Multimediales Lernen im Web, (2001)) a part of the lecture course in “Structural Concrete” was selected for the web-based learning study. The Structural Concrete lecture course (Sparowitz (1995, 2001)) is a required subject for the study of civil engineering. It takes place in the 7th semester in the curriculum, lasting about four months, and is one of the larger lecture elements of the whole course. Every year about a hundred students attend the lecture to learn more about structural concrete buildings. The basic content is the design and construction of reinforced or prestressed concrete structures using the European Standard Norm (EC2 (1992)).



Fig. 1 Pre-fabricated reinforced concrete beam



Fig. 2 Reinforcement

Because of the non-linear behaviour of concrete it is very difficult to describe engineering models and to understand the complex connections between for example stress and strain. Similarly, it is not possible to demonstrate all the important components of the problem via a single experiment. To make the content of the lecture course sufficiently approachable by the audience methods of visualizing the problems were sought (Freytag, Hartl, Stebernjak, Ebner (2001)).

In March 2001 the MML-Project of the University of Technology of Graz was established and three workgroups were founded to investigate the possibilities of Internet use in education. A course-management system called “e-learning suite” (–distributed by Hyperwave : <http://www.hyperwave.com>) has been bought and installed on a server by the computing department. This system represents an eLearning platform with many tools which help to make the communication between teachers and students easier. After the installation the platform has been made accessible to the institutes, mainly to the participants of the workgroups, to assist them with producing course contents. As a consequence, the IBB institute decided to create a multimedia course which is compatible with the platform and which uses the offered communication tools for example discussion forums, virtual office hours and the infoboard (a virtual blackboard). An important condition for the software was its independence of the operating-system, because it was necessary that the applications could be run on every computer. The software required was therefore limited to a browser, the free Adobe Acrobat-reader and the free Macromedia Flash browser plug-in. The IBB’s selected course content consists solely of pdf and html files and some powerpoint presentations. The reason for adopting pdf as the standard is due to its independence from any specific operating system. Consequently, the entire script of the selected lecture course has been converted to pdf.

The animations, which have also been part of the virtual lecture course, have been developed using Macromedia Flash 5.0 (<http://www.macromedia.com>). Flash is an environment for creating a broad range of high-impact content and rich applications for the Internet, like animations, tweenings or simple web pages that require higher design quality than offered by standard html. The main advantage of Flash is the vector based technology, which generates very small files for the internet, necessary for the many students that have very slow access to the internet. It is also very easy to produce visualisations of experiments and describe the corresponding calculations using Flash. Future functionality is also provided for: In future, interactive animations will be produced, where the students can interact the animation thus aiding learning in real-time. Flash offers its own “Actionscript” computer language to assist in generating such interaction.

With these three simple tools, the course can be accessed round-the-clock. From the beginning the aim of the implemented scheme has been to *support* the lecture course with interactive education tools and not to replace it.

The strategy for using this system during the lecture was defined as follows:

- Initially a script of the lecture and further supporting materials, e.g. supporting exercises, were converted into the Adobe PDF-format. The script for the whole course was split into smaller lessons to make the content clearer and more manageable [Fig. 3]. Hyperlinks were also added to the text so that the student is able to navigate through the files.
- Two Microsoft PowerPoint presentations of the lecture content were added to the course-management system, so that the students could work with them at home.
- The tutors created discussion forums (like newsgroups) separated into the major chapters of the lecture. The students discussed their problems with the tutors, allowing misunderstandings to be addressed and further questions answered.
- To describe the more complex engineering problems, twenty animations were created. The visualization allowed experiments and basic facts to be showed on the screen. By incorporating this into the course management system, the students have access to the information whenever and also wherever they want to.
- In the middle of the lecture course, a WEB-CAM was added to allow pictures to be transmitted over the internet. This allowed more complex explanations to be captured directly from the lecture, where the lecturer is able to provide an explanation much more succinctly or clearly than text alone.
- A number of “virtual office hours” (= chats at a fixed time) were held to answer the questions of the students. These were intentionally selected to be between 7.00 p.m and 10.00 p.m, the time when most of the students usually work, and such virtual hours were also held more regularly just proceeding exams.
- The installation of an infoboard offered the possibility to put up-to-date information into the internet, particularly necessary for public announcements such as displacements and so on. This infoboard is comparable with a virtual blackboard, but more efficient.



Fig. 3 Content of the course

3. Didactical Concept

It is important to note that computers cannot improve per se the learning of the individual. Learning is a basic cognitive process, which has to be done by the learners themselves: the Nuremberg funnel does not exist. By using computers for learning purposes, new possibilities of learning arise, however. One of the potential hopes of multimedial learning is that it enables better didactics and in particular increases motivation (Holzinger (2002), Holzinger & Maurer (1999)). Increased motivation results in better learning. The biggest potential advantage is in subject areas where, e.g. through simulation, difficult processes can be clearly visualised in a fashion unavailable to traditional blackboard teaching. Passive consumption of the material does not in itself support learning, however – it is only through interaction with the material that learning processes are supported (Holzinger (1997)). Students do not learn by simply receiving information (Brown, Bransford, Ferrara & Campione, 1983), but rather constructively through a process of reflection on material and interaction with it thereby creating an understanding (Farnham-Diggory, 1990). Thus interactivity is an important ingredient in effective learning by allowing the student to become engaged and to reflect on interesting problem issues. The syntax of a computer programming language can be learned from a book and sample programs. However the design skills and conceptual knowledge are more difficult to acquire from written materials. It has been shown that interactivity in the form of lectures and tutorials is more effective in teaching such concepts than a book and simple programs alone can provide (Aveling, Smith & Wilson, 1992). Interactive learning on the Web may be a way to partially supplement the classroom learning experience by providing an interactive environment similar to the classroom but with more attention to individual student needs (McIntyre & Wolff, 1998).

The conception of educational media begins with the definition of the educational problem. Three aspects are important here:

- Definition of the target audience,
- Designation of the teaching contents and
- Determination of the teaching objectives (goals).

This is the starting point of every professional communication plan as it is, for instance, thoroughly developed and practiced in advertising media. A successful communication strategy in advertising is based on the precise knowledge of the target audience, contents and goals. In contrast, during the production of educational media, a full field analysis is frequently not carried through. For each teaching medium produced and used, it is necessary to ask which educational problem within the framework of the respective project the medium is intending to address. It is also necessary to define and characterise exactly what a group of learners should learn as a consequence of using the medium and/or which knowledge and skills the learners are expected to achieve as a result of learning processes.

The following features can be used for the characterization of the target audience (Holzinger (2002)):

- Social demographic data including social and educational status,
- Prior knowledge (refer to module 2), one of the basic questions during development of eLearning software.
- Motivation: Care must be taken that in the beginning not only the “Hawthorne-Effekt” (Draper, 2001) leads to a learning success. Motivation in terms of interaction is the key indicator of success for this lecture.
- Learning habits: The lecture form uses, e.g. Behaviourism, Cognition or Constructivism.
- Learning duration: The “new way of teaching” demands a change in learning environments, which allow flexibility of learning. The difficulty comes in finding ways to apply the new technologies to a learning process with proven educational benefit (Allen (1998)).
- Attitudes and experiences: Influences like motivation, concentration, humour, social effects, stress and so on must be studied.
- Preferred learning place and media access.

When considering the cognitive learning processes of individuals, the terms learning and learning objectives are used. These terms bring the psychological aspect to the fore. On the other hand, when considering a teaching situation, didactics or educational technology is emphasised and one therefore refers to so-called teaching and teaching objectives.

The following three teaching objectives are differentiated:

- Cognitive teaching objectives – knowledge, understanding, application, analysis and synthesis plus evaluation,
- Affective teaching objectives – attitudes and intrinsic values
- Psychomotoric teaching objectives – movement functions.

A teaching objective specifies what the learners should have achieved after working through the education program and by which parameters (characterizing attributes) this can be observed.

In order to emphasize the communication between the teachers and the learners, the real or virtual, learning place is frequently called an interaction space.

Interaction Space:

For media didactics, the three following questions are particularly important:

- How should the communication space of a medium be designed, e.g. in the internet, in order to secure and/or to increase the learning success?
- Should the interaction by means of defined learning methods progress sequentially?
- Should the possibility of free movement within an open interaction space, in a net of informational units, e.g. hypertext, be given?

These questions have been intensely studied by media didactic researchers for some years. According to Kerres (1999) the decisive criteria for the structure of an interaction space can be summarized as follows [Fig. 4]:



Fig. 4 Structure of an interaction space

4. Experiences

Animations [Fig. 5], [Fig. 8]:

The visualizations have been created with Macromedia Flash 5.0. Essential topics have been animated to improve understanding. The main problem during the creation of an animation of this type is to point out the basics of the matter without showing all the detail: the main principle should be found out by the students. Detail can then be animated in further flash animations.

During the lecture, the simulations are shown via laptop and projector, the content is explained, followed by a discussion with the students about the topic. In this way, the basic information can be given within a very short time. Furthermore the visualization can simulate a virtual experiment: The students can steer the animation

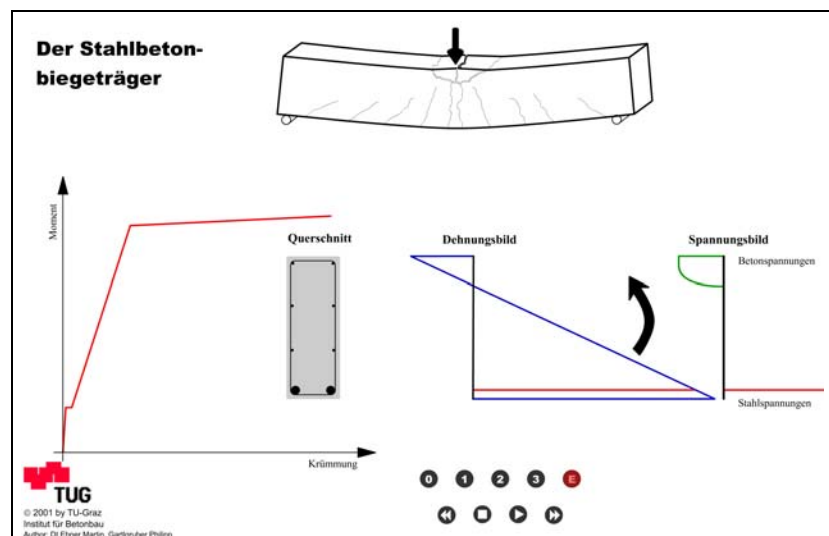


Fig. 5 Reinforced concrete beam

via buttons, stop, repeat or jump to the next part. The animations only require a browser with the free Flash-plugin, ensuring, as previously stated, independence of the operating systems on their computers.

The persistence of the flash animations for teaching is likely to be high due to the fact that the animations developed describe fundamental concepts in engineering mechanics. This would also be the case for animations developed for simulation of building materials and their material behaviour. Because of the increasing interests of the students in multimedia (Hawthorne- Effect) the simulations are also more likely to be reused by the students.

Discussion forums [Fig. 6]/virtual office hours:

It has been identified as very important that the discussions are managed by the tutor, because the students must be confident that there are no mistakes in the replies produced nor in the postings or material they get from the forums. Without such support and supervision of the forums the students would not be interested in such an interaction space.

By holding the virtual office hours at a very late time of day, the users have access to information and tips during their typical working hours. In particular it was found that virtual meetings held on the days before an examination had a particularly high number of participants.



Fig. 6 Discussion forum

Infoboard – the virtual “Blackboard” [Fig. 7]:

The most efficient tool of the course-management system has been the infoboard. It was primarily used by tutors and lecturers as a space for notifying students of all important information regarding the lecture course. The support of such a tool has to be handled carefully and requires a significant amount of time. At the end of the lecture course about seventy postings had been made. This tool is a further step in the direction of location independence, because the students were not required to go to university for information regarding the handling of the lecture: waiting before an empty lecture room seems to be a thing of the past.

5. The results of the evaluation

At the end of the lecture an evaluation of the multimedia project was performed to see whether the project was successful or not. One week before the end of the lecture course, an electronic form was made available from the course web page. About one-third of the students filled in out.

The primary issues raised from the evaluation were:

- The animations were seen to be very informative and the students were able to understand the content much faster and better.
- Necessary computer hardware was seen as a significant limitation, because the speed of modem and web access of most users was very limited and as a consequence the loading time for the sites, in particular the animations, was found to be frustrating. In future, improved data streaming will be required, to allow transmission of the content in real time.
- Only a few of the students tried to read the lecture course script via the web. The main problem seemed to be symptoms of fatigue due to reading on the screen.
- Many of the students pointed out that a multimedia project like ours is a very good additional possibility to improve the quality of a lecture, but the word “additional” seemed to be very important. They wouldn’t want the classic education *replaced* by a web-based project.
- A further point of the evaluation concerned the learning to handle the new platform. For many students the contact with new software means at least a passing handicap.
- Quick answers in the discussion forums or by e-mail were an important issue, that would require support round-the-clock.
- The virtual hours seem to be valuable, but it was found that a number of the problems encountered with the material were difficult to describe in a few words.

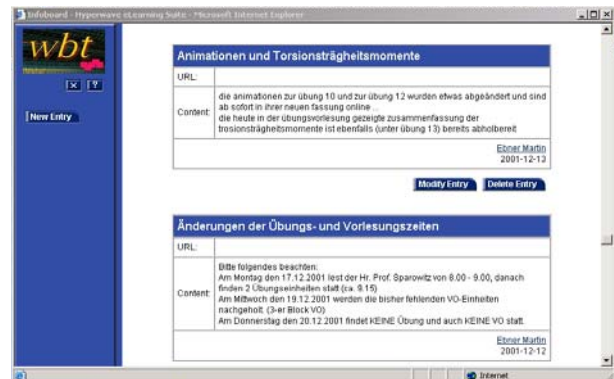


Fig. 7 Infoboard

6. Personal reflections after the “multimedia-lecture”

“Support round-the-clock” is necessary, in order to get the “system” to work smoothly. The pre-condition of every web-based training is a lot of effort from each tutor. The response-time to student queries must be as short

as possible. If it is too long, the students will work without such a system. The level of communication between the students was poorer than hoped, but it is important to remember that the course-management system is new and that it may take some time for the students to get used to it.

The creating of flash-animations was similarly found to take a significant amount of time, but the obvious success shows that the development of such visualizations is inevitable in a modern lecture course for technological studies.

One of the biggest advantages is the time- and location- independence of such a multimedia lecture, because the course-management system can be used from all over the world, only an Internet entry is necessary.

Due to the transfer of information via text only, i.e. without the use of sketches, chats were found to be very difficult to moderate. The trainer has to understand the problem quickly and then to explain it in a few words, but often the questions are not clear enough. Furthermore, it is absolutely necessary that all participants are self-disciplined during a virtual office hour, because the tutor is not able to answer all the questions at the same time. A solution that worked successfully during the study was the use of at least two trainers during one virtual office hour.

7. Discussion and Conclusions:

- For the future audio-sequences should be integrated to activate the sense of hearing in the learning process.
- The animations are an important assistance during the lecture. They give the teacher / lecturer the possibility of an explanation that cannot be realized as easily without visualization. One animation is more valuable than many still images, because in this way cross linked thinking can be stimulated.
- Many students did not take an active part in our discussion forums or virtual office hours, but they read the comments at a later time. This fact is very important, because the tutors can thereby draw the students' attention to problems that the students have not been able to identify themselves.

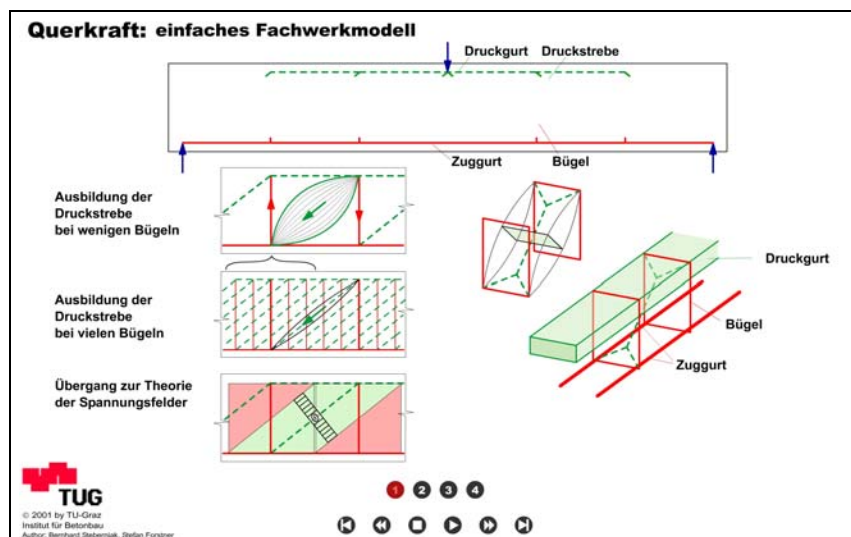


Fig. 8 Animation: Shear force effect

- The primary success of the multimedia lecture was the interaction between the tutors and the students. Only after the numerous discussions in the newsgroups and chats were the real problems in understanding the content of the course material properly identified. These forums also enabled the tutors the possibility to address misunderstandings or perhaps badly illustrated topics. Questions which would not be asked in the lecture room because of shyness or fear of inappropriateness were posed without such inhibition in the eLearning environment. Communication via Web became the main focus for the lecture course. The communication provided the teachers with a common ground for collaboration that generated sustained enthusiasm and discussion (Bransford, Brophy, Williams (2000)).
- Interactive multimedia technology also helped motivate learners. One of the powers of web based training is the capability to engage by providing rapid answers to current problems, and as previously stated, an engaged student is a motivated student (Neorman & Spohrer, 1996).
- A further development to the project could be creation of e.g. multiple choice test tools where the students can test their knowledge, because many students requested such a possibility.
- In future it would also be necessary to improve the technical equipment of the students, because transmitting static pictures via Web was found acceptable via modem, but videos etc. took too much time.

- The feedback of the students and the tutors / lecturers showed that this form of education was a step in the right direction and was sufficiently successful to ensure the project's continuation for this particular lecture course for coming years. It is also hoped to expand such an approach to other lecture courses.

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