

e-Learning in Civil Engineering – Six Years of Experience at Graz University of Technology

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Abstract: At Graz University of Technology a lot of experience in the investigation of possibilities of using Multimedia or Internet based applications in Higher Education has been gathered. Especially in the field of civil engineering we can look back to six years of practice in this field.

In 2001 the project iVISiCE (interactive Visualizations in Civil Engineering) was started. A great number of web based animations, visualisations and interactive learning objects have been developed for visualisation and simulation of basic structural concrete relations.

During the last two years the buzzword Web 2.0 shocked the traditional e-Learning World. The Internet got more interactive and usable for end-users. Phrases like “user-generated-content” and “give-and-take-culture” pervade our daily life. From this point of view the Institute of Building Informatics decided to teach using these new tools in order to gather experiences and to play a kind of pioneering role in this field. Since winter 2005 a Wiki is used to support the main lectures of the institute. Students wrote articles themselves and collaborated in the process of learning a programming language. Finally, since this semester Podcasting has started. This means that each lecture is recorded and provided to the students in various file formats.

The paper gives an overview about all activities within the last six years. Beginning with animations and ending with the use of Web 2.0 applications, like Wikis or Podcasts, we have always tried to ensure high quality of our education. In the summary it is clear that these small, but regular innovations definitely helped to improve the lectures in the field of civil engineering.

Keywords: e-Learning, Building Informatics, Structural Concrete, Web 2.0, Wiki, Podcast

Introduction

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

(Mark Weiser, 1991)

Mark Weiser (Weiser, 1991) postulated the need of digital end-user devices which are completely integrated in our daily life. Long before personal computers were available in nearly each home, long before mobile phones were used by nearly everyone, long before Internet access was realized for nearly whole world, he talked about pervasive or ubiquitous computing (Matten, 2003). Similar to the emerging improvement of hardware (computer and network) the World Wide Web offered great possibilities for new business areas – the New Economy was born during the turn of the millennium. e-Learning was one of the new fields, which promised to revolutionize the area of teaching and learning - “The World Wide Web offers educators a new medium to deliver teaching and learning material – one which bring new and exciting ways of learning, and an alternative to traditional teaching techniques” (Allen, 1998) – this was one of thousands similar statements in the very first beginning. A lot of projects, international and national initiatives were started to support the teaching and learning process using these new technologies. Especially institutions of education spent power, time and money to improve their lectures. But if we look back and summarize, was e-Learning successful? Could e-Learning meet the high expectations? How did the possibility to work online change our teaching and learning behaviours?

Of course, also Graz University of Technology began to use the Internet for teaching and learning purposes and since then a lot of experience in the investigation of possibilities of using Multimedia or Internet based applications in Higher Education has been gathered. Especially in the field of civil engineering we can look back to a six years of practice in our lectures. In this publication we like to give a short overview about all e-Learning activities of the Faculty of Civil Engineering, especially in the area of structural concrete and building informatics.

The change of the World Wide Web

During the last decade the World Wide Web has evolved into a large worldwide network as it was announced by many computer experts in the early 1990's. The idea of Tim Berners-Lee (Berners-Lee, 1989) that everyone can contribute to this network can be remarked as starting point for this development. Digital content as well as multimedia files could be distributed on the Internet by a simple uploading process. The so called first generation of the web was a conglomerate of static web pages mostly made by web designers or people with programming knowledge. Communication and interaction were mainly restricted to eMail, newsgroups, chats and instant messaging. The situation for e-Learning was similar: learn or course management systems offered these functionalities.

Nowadays, the buzzword Web 2.0 (O'Reilly, 2006) and its applications changed the possibilities of the Internet dramatically. Weblogs, Podcasts or Wikis and other Web 2.0 features allow the typical end-user to be an active participant without any special programming knowledge. The "traditional" e-Learning world is currently moving towards these techniques (Ebner et. al, 2007).

From one way to learner-driven, from macro to micro content, from formal to informal learning, from courseware to Wikis – however, the incredible speed of raising possibilities must be proved very carefully. A lot of research work in this area will be necessary, but it can be pointed out that currently e-Learning 1.0 is replaced by e-Learning 2.0.

Learning – Theoretical Background

At the very first beginning we must note that multimedia cannot improve per se the learning of the individual. Learning is a basic cognitive process, which has to be done by the learners themselves (Wilson et al, 1974), (Hall, 1989), (Solso, 1995). Until now, the often adduced Nuremberg funnel, in which knowledge is poured into the heads of learners, is not realizable. With other words the learning outcome cannot be improved by simple content providing.

Teaching and learning are both social processes and are happening between people: teachers are interacting with learners, learners are interacting with other learners and since few years there is a new kind of interaction – between learners and computers. The possibility of interaction is absolutely necessary, because learning as a highly social process proceeds through and bases on conversation (Dewey, 1916), (Holzinger, 2002). Learning needs immediately feedback in the same way as user-dependent reactions.

A further advantage of using multimedia is the aspect of motivation. By increasing motivation learners can be engaged or attention to the learning material can be hold for a longer period of time.

Due to these facts it must be pointed out that the strength of the World Wide Web and multimedia in education lies mainly in the collaboration aspect. The chance of improving the learning behaviour is to expand the lecture room with new possibilities. The worldwide access to the content as well as to communication tools helps to support learning processes and is often expressed by the famous A³ (anytime, anywhere, anybody).

Web 2.0 technologies allow another step forward – the learner him/herself can actively participate. He/she is no longer just a content consumer but he/she now also has a possibility to write his/her own contributions, to collect and share his/her preferred learning content and

to play a much more important role in the whole learning context. Didactical concepts based on the constructivism learning theory can be supported in a much better way as years before.

Experiences with Internet technologies in Higher Education

In the following text some examples from Graz University of Technology which were made during the last six years are presented.

The project iVISiCE

Since the end of 2001 the e-Learning project iVISiCE (Interactive Visualisation in Civil Engineering) has supported lectures in the field of civil engineering at Graz University of Technology (Ebner & Holzinger, 02). With the aid of a learning management system (Ebner et al., 06) appropriate content has been made accessible to the students. Due to the fact that a student of civil engineering has to gain an intuitive understanding of structural behaviour the education is strongly based on visualisations. Furthermore, one the strengths of multimedia is that multimedia provides more descriptive sequences by using graphical animated elements. Bearing in mind the didactical concept and the teaching situations in the lecture room, three key aspects were defined (Ebner & Holzinger, 04):

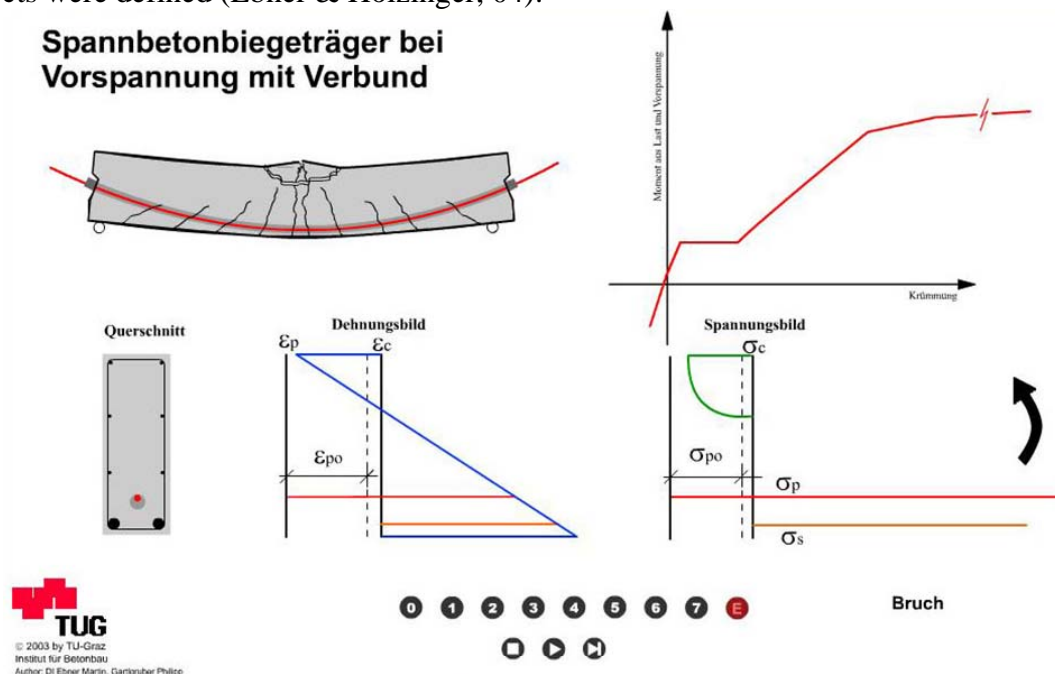


Fig. 1 Animation of a prestressed concrete beam

- Communication: As mentioned above, learning processes are social processes between teachers and learners. As a consequence communication tools must be provided to enable getting in contact, discuss or simply asking questions. To bring lecturers and students more in touch leads to a more in-depth learning (Lee Price & Lapham, 03). During the lecturers computer-mediated communication was used in various ways – asynchronous (discussion forum, eMail, virtual blackboard, thematical uploads) as well as synchronous (chats, virtual office hours, video chats) tools were used. In the summary of experience shows us that these tools are absolutely necessary for online learning and teaching (Ebner & Holzinger, 05).
- Visualisation: The second main part consists of a number of animations and visualisations. Complex engineering problems are mainly explained in a graphical way. The traditionally way is to draw it on the blackboard or overhead transparency. If there are trajectories or movements the explanations was limited to different pictures. The goal was to improve the understanding of engineering problems by

animating essential topics: for example fig. 1 shows a prestressed concrete beam with related stress, strain and bending line.

- Interaction: Bearing in mind that a learning process can be activated by actively engaging the learners to do something, so called Interactive Learning Objects (ILO) were programmed. Each ILO consists of three parts (Ebner & Holzinger, 2003):
 - 1) Information and learning material: Consists of the information about the learning material and the material itself.
 - 2) Communication: Possibilities to get in the contact with the lecturers.
 - 3) Assessment: Allow the students to monitor their learning process and determine where they need more practice on their own.

Fig. 2 shows the developed game “Internal Force Master”, where students can train their knowledge about internal forces. Within a short time frame the learner has to choose the correct answer. Otherwise the game ended and the high-score list is presented. After running for four years now, I can be pointed out that the game helped to increase the learners’ motivation.

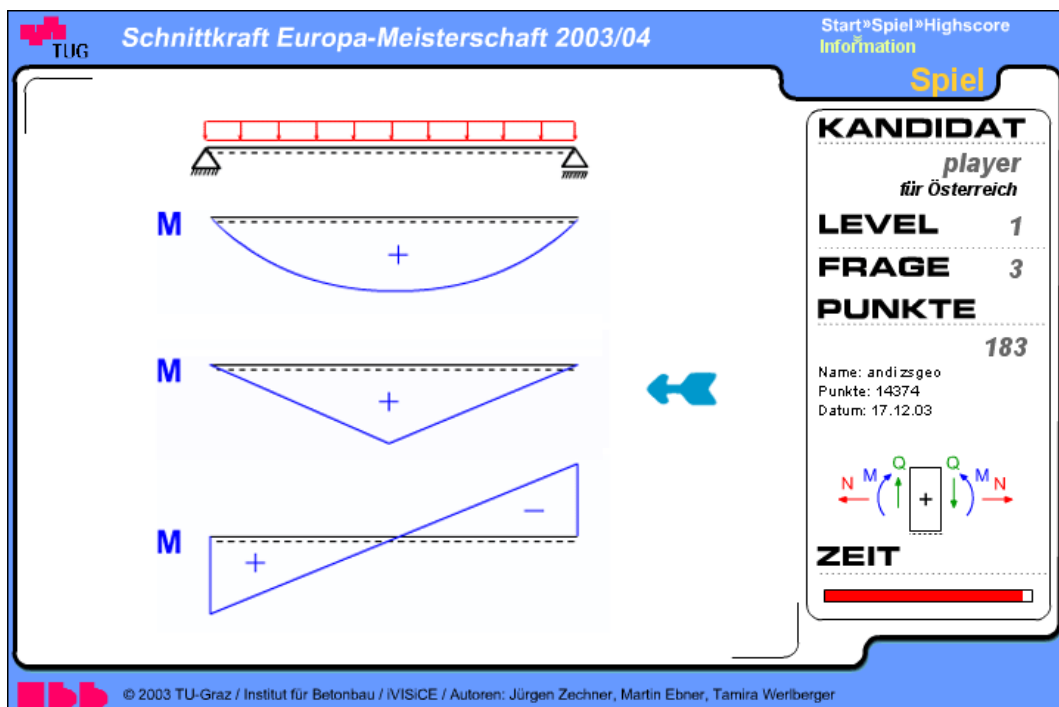


Fig. 2 Online game

Engineering Software

When analyzing subjects like mechanics and structural analysis as they are taught today during the first 6 semesters at the faculties of civil engineering sciences, one notices that for over 50 years almost nothing has changed regarding contents and teaching methods. Teaching the basics of structural analysis, in particular equilibrium and the effects of forces on idealized structures, is done primarily by using mathematical descriptions of physical laws and some graphic methods. However, in this early phase of their studies students do not yet really understand the application of mathematics to practical problems. Therefore the success in learning is small and limited to adopting certain methods for selected special cases. Only the best students take the step from "knowing" to "understanding". As a result time must be spent in following lectures on the repetition of basic knowledge, taught already in previous courses.

Today all those hand methods have been replaced in practical civil engineering by one, the finite element method. This method presupposes the use of computers and causes the

didactical difficulty that the understanding for statics, acquired so far in innumerable computations by hand, has to be achieved in a new way. However, the so called „feeling for statics” cannot be gained in solving problems with commercially orientated FE-programs, as the theory on how to get a solution is completely hidden within the program.

In the second course on structural analysis, one tries to introduce beside the traditional methods new teaching techniques which pursue the following objectives:

- every step is repeated on a large number of examples,
- programming replaces hand computation,
- simulation is more important than computation,
- detailed knowledge on the theory of finite elements is only taught in the master program.

When using the finite element method the step from understanding statically determinate to indeterminate structures takes place completely naturally, which is not possible with the hand methods. However, employing this method makes it more difficult to teach the theory behind it. Practical programs are not suitable here, too, as the interaction of forces, constraints and transfer of forces cannot be experienced in real-time. For this purpose model tests would be most suitable, but they are difficult to adopt in the lectures in a consistent way. To solve this discrepancy a didactical statics simulator program has been developed at the ETH Zurich, which is called EasyStatics (Anderheggen and Steffen, 2003). It can be used intuitively and offers an absolute real-time simulation of statical computations for arbitrary frames and trusses by theory of 1. and 2. order, including stability, eigenvalue and rigid-plastic computations. In up to four different windows variations of a structure or a theory can be simulated simultaneously.

In shortest time the influences of varying geometry, load positions and boundary conditions can be studied. The effect on deformation, interior forces and cross section resistances are visualized graphically. The real-time calculation permits a continuous simulation of different conditions and to directly experience the reaction of the system.

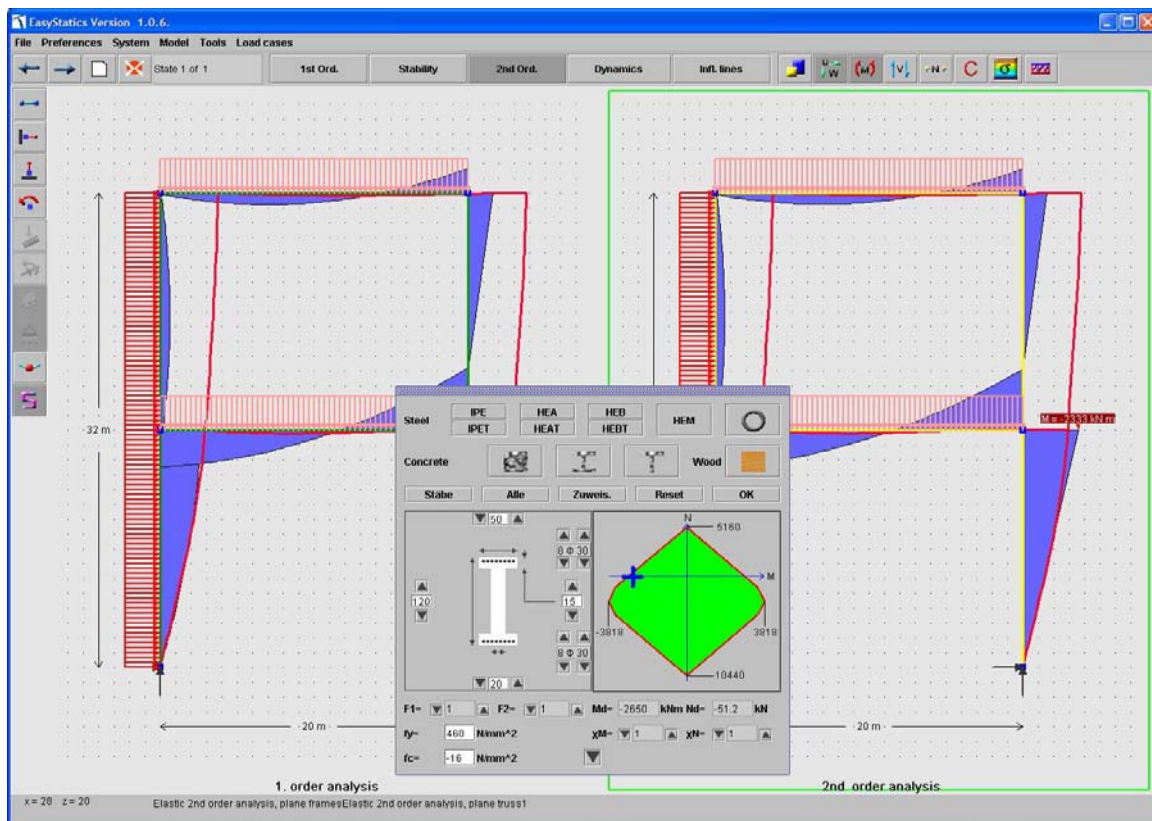


Fig. 3 EasyStatics for realtime simulation

Bauwiki

The concept of Wikis was introduced by Bo Leuf and Ward Cunningham in 1995 (Leuf & Cunningham, 2001) with the aim to develop an easy-to-use knowledge management system enabling effective and efficient online collaboration. With a Wiki each user is able to create, edit, revise or link articles – just on demand.

The most known and famous Wiki is the online encyclopaedia Wikipedia with more than 4 millions articles in 100 languages. The main concept is that anyone (even in an anonymous way) can edit or change existing articles or maybe write a new one. On the basis of a world wide community, which is working completely voluntary, the world largest encyclopaedia has been created. Of course the success of collaboration is very interesting for learning purposes if we consider that team working is an essential part of the curriculum.

The Institute of Building Informatics decided to launch a TWiki (one of 200 different open source Wiki systems) for the first time in the beginning of 2006. The aim was to support the lecture Computer Science II for students of civil engineering by creating a knowledge base for searching and retrieving information on visual basics programming language for applications (VBA). Students were supposed to use the Wiki during the whole semester, extending and refining the articles in the Wiki. As basic motivation students were allowed to use this content in the written exam. Fig. 4 shows a Wiki page from this lecture.

The screenshot shows a Wiki page for 'VBA' on the 'Bau-TWiki' website. The page title is 'VBA' and the breadcrumb is 'Bau-TWiki > VBA > IfVerzweigung'. The main content area is titled 'If Verzweigung' and contains the following text:

Mit Hilfe einer If-Abfrage kann man Teile eines Programmes ausführen, wenn eine bestimmte Bedingung erfüllt ist.

Der **Syntax** lautet:

```
If (Bedingung) Then [Anweisung]
```

Für die Bedingung stehen die [VergleichsOperatoren](#) zur Verfügung.

Weiters ist eine beliebige Schachtelung des Befehls mittels der ElseIf Anweisung möglich. Hier lautet der Syntax:

```
If (Bedingung1) Then
Anweisung
ElseIf (Bedingung2) Then
Anweisung
Else Anweisung
End If
```

Below the code example, there is a section titled 'Code Beispiel' containing the following VBA code:

```
Private Sub Form_Open(Cancel As Integer)

'Variablendeklaration
Dim strEingabe As String

'Eingabeaufforderung
strEingabe = InputBox("Geben Sie eine ganze Zahl ein:", "Eingabe einer Zahl")
```

The page also features a sidebar with navigation links such as 'Login', 'Logout', 'Hilfe', 'Registrieren', 'VBA', 'Home', 'Themenliste', 'Mitglieder', 'Änderungen', 'Suche', 'TWiki Webs', and 'Links'.

Fig. 4 Bauwiki (<http://bauwiki.tugraz.at>)

In a second attempt the lecture Computer Science I for Civil Engineering was supported by a Wiki system. The first step was to create online articles. Comparable to Wikipedia each student had to write an article about a special civil engineering topic (for example structural concrete). On the one hand students learned a primitive form of hyper language and on the other hand the end product was an encyclopaedia of more than 150 pages.

Podcasts

The term “Podcast” is a mash of Apple’s mp3 player “iPod” and the word “broadcast”. A definition of “Podcast” as Wikipedia explained it “A podcast is a media file that is distributed by subscription (...) over the Internet using syndication feeds, for playback on mobile devices and personal computers.”

With other words only the combination of a media file with the RSS technology, where users are able to subscribe can be named as Podcast. The use of Podcasts in Higher Education is mainly a recording of the entire lecturers – audio (the voice of the lecturer) and video (capturing the computer screen of the lecturer). This file is post-worked and afterwards distributed online in four different formats: .avi (all operating systems), .mp3 (only audio), .swf (navigatable through all slides) and .m4v (the iPod file). With this file types nearly all devices can be supported. Fig. 5 shows a screenshot of a Podcast of the lecture Computer Science I.

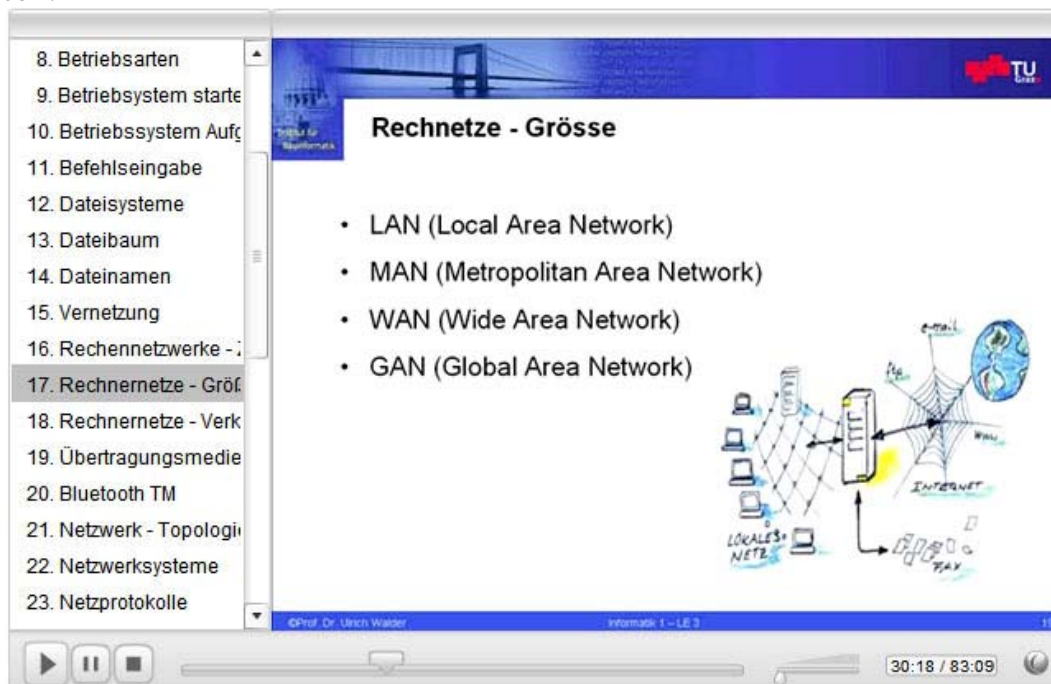


Fig. 5 Podcast of lecture Computer Science I

Discussion

After six years of experience in e-Learning, especially in the field of civil engineering we share the opinion of many of our colleagues: teaching and learning are very heterogeneous processes with more than one possible solution. Maybe there are more solutions than available didactical concepts – that is one problem which must be considered.

It can be pointed out that e-Learning has a great potential to support lecturers in various ways. Since Web 2.0 technologies there are many new possibilities for support the learning process.

We like to summarize our main principles:

- Didactical concept: The starting point is always the didactical concept. How and what are the lecturers teaching? What is the goal of the lecture and what should be the learn outcome? What is the type of the lecture?
- Systematic support: E-Learning support should be very systematic and flexible. The lecturers should only use tools or applications they really need. A high number of tools which are never used lead to very negative experiences for all participants.
- Learner Centred approach: A main principle is to support the learning process, but this also means that the typical learner should be involved in the programming

process. Usability processes have attended all implementations (ILOS, animations) to ensure that the learning material is easy to use (Holzinger & Ebner, 03).

- Community based: Learning and communication are linked inseparably. Learning is strongly based on questions and if teacher and learner are able to discuss problems this leads to a more in depth-learning (Gallin & Ruf, 93). From this point of view communication tools are a core necessity.
- Device independence: Due to the fact that a lot of different devices with even more operating systems are available, learning materials should be developed independently from it.

Conclusion

On one hand the explosion of knowledge in all areas of the building industry and at the same time the demand for a rationalisation of the curriculum, caused by the introduction of the Bologna model, asks for a fundamental change of today's teaching and learning methods. Today's still unexhausted possibilities of e-learning and e-teaching, as well as the rapid development of mobile intelligent devices (smart phones, play stations) should be used more efficiently. The development of special simulation programs, such as EasyStatics, show a new way of knowledge transfer.

On the other hand, the danger that students get lost in the flood of electronically available teaching material can not be neglected. An international exchange of experiences would be very helpful.

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