

E-LEARNING APPLICATIONS IN THE EDUCATION OF ENGINEERING DESIGN

Dipl.-Ing. Z. Marosváry, Prof. Dr.-Ing. S. Vajna

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1. Introduction

Engineering Design is an important, determining process in the product life cycle. New methods, working principles and procedures as well as computer-based tools are researched, implemented and applied in this area. To provide young designers with current knowledge for their professional life, new results of this research have to be established in the education of mechanical engineers. It will be more and more difficult to meet the permanently increasing requirements of industry by conventional methods of education. For this reason, rearrangements are necessary in the area of educational methods. One of them is the intensified application of new media in education and training.

First attempts to use computers as supporting tool for education were accomplished in the 1970ies in the USA. The real distribution of E-Learning systems took place in the 90ies of the last century due to the emergence of the Internet [Niegemann, 2004]. Previous advantages of using multimedia have been completed by the possibility of synchronous co-operative learning. Frequent updating of contents and linking internet contents to learning systems are since then easy to realise.

Research results and practical experiences agree upon that applying new media in higher education or industrial further education has economical, didactical and learning psychological benefits. The travelling expenses and costs of non-productive time can be reduced by using E-Learning applications. Actual learning psychological approaches put emphasis on individual learning, co-operative learning and detecting learning. These learning forms can be effectively supported by E-Learning. The independence of location and the possibility to chose between different learning styles facilitates individual learning. In addition, E-Learning platforms provide several communication tools to assist the cooperative learning process.

To utilise the benefits mentioned above and to enhance the quality of education, the German National Ministry for Education and Research (BMBF) initiated a support program for the propagation of E-Learning at university level.

2. Implementation

Within the scope of this support program, six German universities (Bremen, Gelsenkirchen, Ilmenau, Karlsruhe, Magdeburg, and Rostock) started the project Pro-Teach-Net in 2000. The topic was to develop an education network for Product Development and Engineering Design. The project gained the support of the ministry, so the consortium started to build up the educational portal in 2001.

2.1 Objective Targets

Main purpose of the project was to generate a novel electronic platform to support the education of Engineering Design. Further aims can be collected as follows [Zirkel, 2002]:

- supplement the traditional educational forms,
- application of multimedia to improve the learning process,
- possibility for decentralised upgrading,
- support of the team-oriented and project-oriented cooperative Engineering Design work.

2.2 Application

The relation of traditional lectures and supporting electronic learning matters can be specified in percentage. In this manner the proportion of electronic learning matters in distance learning converges to 100%. In case that a teacher shows only one or two pictures or tables during a traditional lecture, the proportion of computer support tends to zero.

Pro-Teach-Net was intended to support traditional education, therefore the part of electronic contents are targeted at maximum 50%. The elaborated platform Pro-Teach-Net can be used:

- for preparing to lectures individually or in groups,
- as electronic assistance during lecture,
- for handing out and collecting student exercises,
- voluntary monitoring of learning improvement,
- for carrying out written examinations and
- as communication platform for distributed Engineering Design projects.

3. Results

3.1 Configuration of the Webportal

Diverse learning platforms were compared based on a benchmark-matrix in order to choose an optimal platform. Several preselected systems were tested by the institutes. Considering the requirements concerning students, tutors and IT-systems the platform WebCT has been chosen.

The elaborated electronic contents are based on the curricula of the participating institutes. The arrangement of subjects in different modules makes the generation of student accounts easier. Modules A – E contain subjects for the basic study period. The product-development-oriented subjects of the main study period are collected in the modules F – J (table 1).

Table 1. Topic of Modules

| Basic study period | |
|--------------------|---|
| Module A | CAD basics, descriptive geometry |
| Module B | Basic principles of design |
| Module C | Basics of structural mechanics |
| Module D | Machine elements |
| Module E | Task collections, tutorials |
| Main study period | |
| Module F | Design methodology |
| Module G | Special CAx methods |
| Module H | Projects of virtual product development |
| Module J | Industrial case studies |

Figure 2. shows the layout of a content page. Exploiting the possibilities of multimedia, numerous pictures, figures and tables illustrate the textual contents. For some more complex coherences animations and videos were created.

The menu on the upper side is used for navigating within the subject (forward, backward, back to contents, reload page). Tools and domains of the module (homepage, curriculum, calendar, content, tests and communication tools) are available through the left-side menu. Communication tools (e-mail, chat, forum, whiteboard) provide a significant advantage compared to traditional lectures. By means of it, students can discuss the topic of a lecture among themselves or they can ask the lecturer special questions.

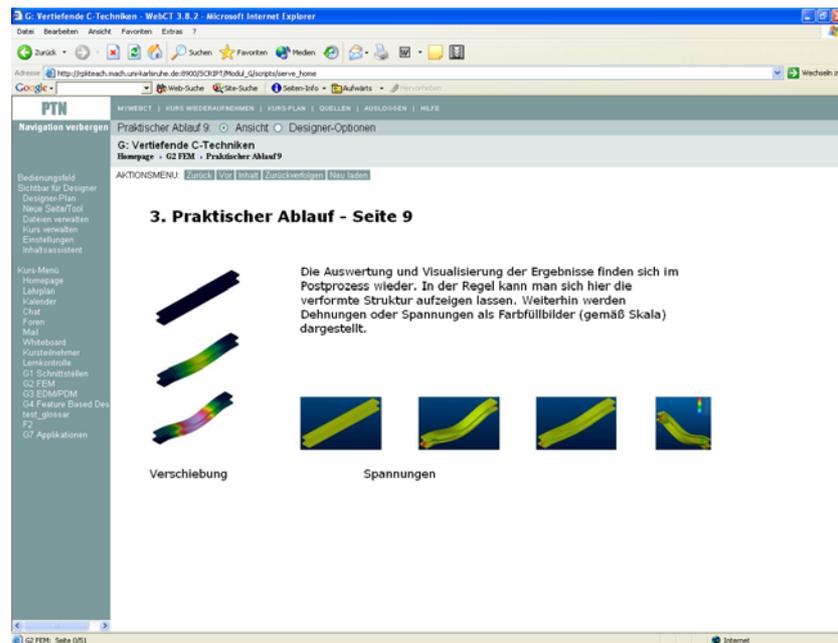


Figure 2. Layout of a content page

Accomplishing design exercises belongs by nature to the education of Engineering Design and product development. These exercises support transferring of learned matters into practical use, and assist the memorising process by generating experiential connections. Engineering Design in industrial daily routine is carried out almost exclusively by teamwork, often in cooperation with external design bureaus, suppliers or customers. One main focus of such distributed Engineering Design projects is communication. To arrange the tutorials according to these industrial conditions, the realisation of collaborative Engineering Design projects is as well provided within the platform. Module H is destined for data exchange and coordination of these projects. Besides the several communication tools of WebCT, an extern videoconferencing tool and a CAD collaboration tool are applied for this purpose.

For monitoring the learning progression the platform provides following checking alternatives:

- Tests or self-tests in form of multiple choice questions, matching questions, arithmetic tasks or open questions and
- Exercises and essays to submit via the platform.

The evaluation can effected potentially fully automatically (e.g. tests with exclusively multiple choice, or matching questions). Based on the evaluation the student receives a feedback of his learning progression.

3.2 Application of Content Modules

The platform has been successfully in use since March 2003 by all partner universities. At our chair accounts for 70 students were generated for 2 modules supporting a lecture. Using

the platform was recommended however not compulsory. The activity of the students, the usage of modules or pages can be reviewed by logging in with designer rights on the platform. This helps to analyse the platform-usage. In the first active semester:

- 73,1% of the students did not used his account,
- 18,2% logged on only once,
- 8,7% used the system regularly.

In the next semester other 30 students got an account, and 3 more modules were activated. The usage had slightly improved:

- 67% of the students did not used his account,
- 19,2% logged on only once,
- 13,8% used the system regularly.

3.3 Engineering Design Exercise

The first collaborative Engineering Design exercise has been realised in 2003 by 6 student groups. The task for the 20 students was to develop a packaging machine for shrinkable tubing.

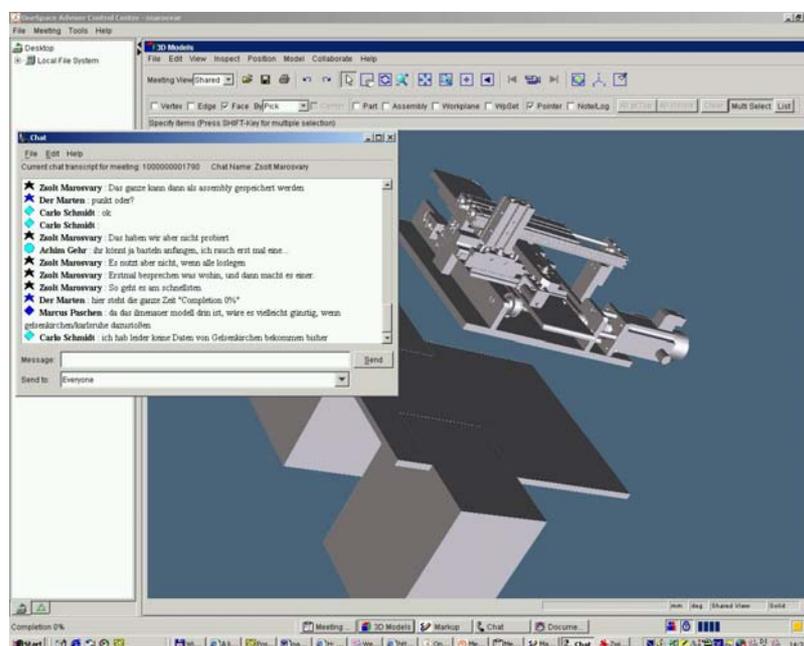


Figure 3. Assembling the modules via CAD collaboration

In view of the task definition the teams had to work out own requirements lists, structures of functions and solution principles. In between the single design versions were opposite evaluated, then the best version was chosen or the benefits of more versions were combined to a new one. In the embodiment design phase each team had to design one module of the machine. Finally the modules were assembled during a special videoconference.

Pro-Teach-Net served in this project as an all-round tool for communication and data exchange. For videoconferences the Swedish Marratech software has been used. This tool was chosen after a benchmark with iVisit, Netmeeting et al. Marratech provided the best video and sound quality by multipoint conferences. In the later design phases the created modules were checked for matching and assembled via the tool Onespace of the company CoCreate. The software enables visualisation and simply design changes of CAD models for more client stations concurrently. However, it is not recommended to use OneSpace for design changes. Since the CAD models have to be converted to a neutral format (STEP, IGES) for being used in OneSpace, parametrics of the models get lost.

4. Results and Conclusions

4.1 Personal Opinions of the Students

The students filled out a questionnaire about their experiences with Pro-Teach-Net. The results of this questionnaire are summarised as followed:

The time needed to get to know the system and to get used to the system is according to the students opinion evanescent. User interface and access potential are rated good and the represented contents were assessed positively as well. Problems occurred only by loading some pages via slower internet connections, this led rarely to delays in loading. 42% of the students means, that Pro-Teach-Net is only a partly adequate supplement for the lecture. The students were not obligated to use the platform, so nearly 70% not even once logged in. This phenomenon is based on the present structure of the traditional lectures. These provide all information and knowledge required for a successful exam.

4.2 Design Exercise Experiences

Focal point of the collaborative design project was of course communication [Vajna, 2004]. Different researchers came to the conclusion, that personal connections are essential for distributed Engineering Design projects. People with personal contact work together more effectively. The Pro-Teach-Net experiences are similar: all participants agreed, that besides the kick-off-meeting more personal meetings would have been necessary. In addition, the overall view of the participants was that the available electronic communication tools are not sufficient for that kind of collaboration.

All performed video conferences were technically trouble free. Our experience shows that for running Marratech and OneSpace on a computer simultaneously, approximately 512MB RAM and a Pentium 4 or equivalent processor is needed.

5. Outlook and Future Work

In the last 4 years, BMBF financed the development of exactly 100 new E-Learning solutions [DLR, 2004]. The total number of E-Learning projects is surely a multiple of this number. Today it is obvious, that these systems cannot meet the inflated expectations. Niegemann et al. [2004] present some problems:

- Representing contents by multimedia means *alone* does not lead to build up usable and stable knowledge,
- Refreshing contents with multimedia brings not measurable motivational benefits,
- Problems of personal collaboration appear intensified by collaboration in virtual teams (because of the desiderative visibility of participants),
- Too much autonomy of the students results in high abort rates.

In the near future, these shortcomings of the produced E-Learning systems have to be fixed, in addition the systems have to be sustainably integrated in the ordinary education. For this purpose mainly organisational actions are necessary. Personal and organisational preconditions to enable propagating electronic support systems for the education have to be created. The existing prototype systems have to be adapted to their „customers“, i.e. mainly students and practitioners, who look for additional training to freshen up their knowledge.

These are the aims of the newly announced support program of BMBF as well. In the framework of this program, new organisational models have to be elaborated that enable an increased use of E-Learning systems. In addition these models have to raise the quality and efficiency of education and to obtain new national and international user groups. Besides developing new organisational models, the project have to take care of:

- refining existing learning materials,
- user support,
- national and international marketing,
- quality assurance and

- management of copyrights.

The long-term aims of BMBF are characterised by the fact, that one primary criteria of the evaluation of applications will be the quality of the self-financing-plan after the end of the governmental support. Recently the partner institutes elaborated and submitted a corporate application. According to this, the future steps can be subsumed in 3 points [Müller, 2004]:

- Elaborating an organisational model for the long-term self-financed operation,
- Extending the platform contents and user groups, as well as
- Establishing/Integrating the platform into the university education.

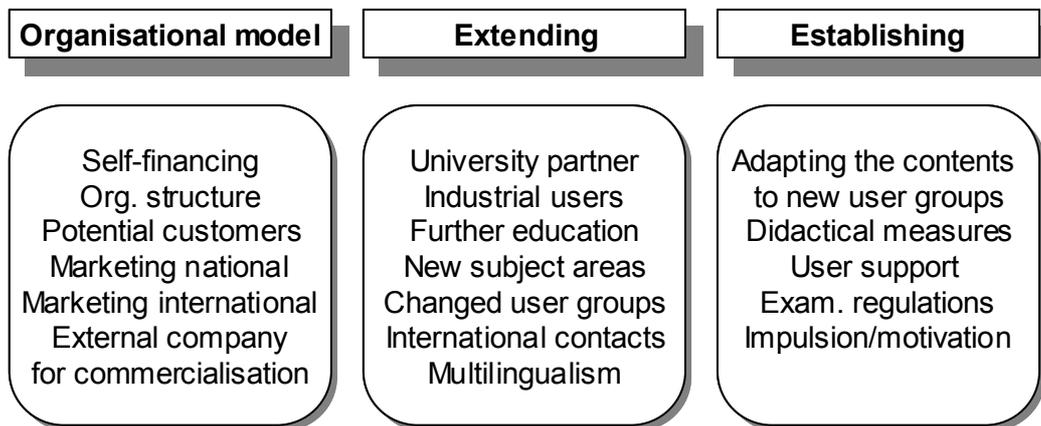


Figure 4. Major topics of future work

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Dipl.-Ing. Zsolt Marosváry
 Chair of Information Technologies in Mechanical Engineering
 Otto-von-Guericke-University Magdeburg
 Universitätsplatz 2, Magdeburg, D-39106, Germany
 Tel.:0049-391-6718097
 Fax.:0049-391-6711167
 e-mail: zsolt.marosvary@mb.uni-magdeburg.de