MADIN – AN INTERNET-SUPPORTED TEACHING AND LEARNING SYSTEM IN MATHEMATICS TEACHER EDUCATION

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MaDiN is an Internet-based teaching and learning system for the teaching of students preparing to become mathematics teachers. It will be integrated into a traditional lecture, helps lecturers to prepare and to give their lectures and supports students to prepare and repeat the contents of the lectures. A web-based course-tool was developed within the frame of the MaDiN-project, which matches the requirements of teacher students in mathematics education and elementary mathematics. The MaDiN-system was used in the lecture "Didactics of Geometry" for high school teachers in the 2002/03 winter semester. A formative evaluation of this course shows how the students accepted the system and how they worked with it. There are also some indications of improvements or at least changes in the students' understanding of the contents.

1. Goals of the MaDiN System

The goal of the MaDiN project (MaDiN = **Ma**thematik **Di**daktik im **N**etz, in English: Didactics of Mathematics via the Internet) is the development of an Internet-based teaching and learning system for university teaching of mathematics teacher students. It is a joint project of five German universities (Nürnberg, Braunschweig, Münster, Weingarten and Würzburg) who are conducting the project in partnership. The project runs from 2001 to 2004 and is funded by the German government. The system supports the lecturer to prepare and give lessons for teacher students in mathematics education (didactics of arithmetic, geometry, algebra, calculus, stochastics, new technologies) and in elementary mathematics (arithmetic, geometry). It is used *in addition to* the lecture and *not instead* of the lecture: more specifically, the system consists of knowledge-based modules, which are designed

- *for the lecturer*, helping the lecturer to prepare and give the lecture and providing him with examples, problems, supplementary texts, pictures, videos, animations and constructions;
- *for the student*, helping the student to prepare and to repeat contents of the lecture, but also to study supplementary contents on his own.

The system stimulates the student to learn on his own, provides possibilities of controlling his knowledge and fosters the communication both between students and the lecturer and among the students.

Within the frame of this project we address the following goals:

- Developing and designing an adequate system (on the software level), which supports the (traditional) lecture with Internet-based materials;

- Supporting the learning and understanding of the contents, traditionally taught in student classes in mathematics education and in elementary mathematics, by taking advantage of the new possibilities provided by the Internet;
- Developing vital abilities – which are especially important for teachers – such as personal responsibility, working in teams and communicating about mathematics.
- Developing and enhancing the theory-practice-relationship in teacher education by providing authentic pupils' materials and requiring students to contact pupils and teachers at school via the Internet but also in face-to-face meetings;
- Getting students to know how new technologies – especially the Internet, but also CAS, DGS and spreadsheets – may be integrated and used in the learning process.

2. Theoretical Framework

2.1 The Internet and Mathematics Education

Teacher students need to be familiar with a variety of technologies and an understanding of how technology relates to the teaching and learning of mathematics. We endorse a view of these new technologies that was proposed by Pea back in 1987: that cognitive tools can help us restructure and reorganize our acting and thinking. From this perspective, new technologies offer opportunities not only to address old purposes, goals and means in new ways but also to define new purposes, new goals and new means that have not been considered before.

With respect to mathematics teacher education, we see the following aspects of the Internet. It is a

1) *source of information*: Students have access to articles, reports, special electronic publications, web-based instructional materials, etc.;
2) *source of classroom materials:* It provides ideas and resources for teachers and students to prepare lessons or classroom reports or talks;
3) *medium of demonstration* in the classroom: for example, there are possibilities of getting dynamic visualisation of theorems and proofs[2];
4) *tutoring and learning system*: it supports students during their homework[3] and allows them to ask individual questions via the Internet[5];
5) *catalyst for collaborative work:* the Internet may support or initiate project, group and partner work[7];

2 E. g. http://www.ies.co.jp/math/java/ or http://www.ies.co.jp/math/java/pythagoras.html.
3 E. g. "Mathe online": www.univie.ac.at/future.media/mo/.
5 E. g. the "Math forum": http://forum.swarthmore.edu/.
7 E. g. BSCW = Basic Support for Cooperative Work (http://bscw.gmd.de/), see also Fischer 2002.

6) *communication tool:* providing student-teacher and student-student communication.

MaDiN is an Internet-based system and we tried to address all these aspects in the frame of learning mathematics.

2.2 New Technologies and University Lectures

Back in 1993, Diana Laurillard classified the various educational media according to their support of the different aspects of the teaching-learning process. She contrasted

- *discursive media*, which enhance the discussion between teacher and learner,
- *adaptive media*, if the teacher plans the use of the media,
- *interactive media*, which are for students' use,
- *reflective media*, which give feed-back to students' actions.

In MaDiN we are trying to show the Internet as a medium which contributes to all of these aspects.

Concerning the role the Internet plays in university lectures, Schulmeister (2001) classifies four different aspects of relationship between the traditional lecture and the use of the Internet:

1) A traditional lecture with the occasional use of the Internet;
2) The Internet plays a crucial role in the lecture; in particular, the students have the opportunity to interact with the Internet;
3) The lecture is given to some extent as a virtual Internet-based lecture,
4) A virtual Internet-based lecture.

The researchers and lecturers who are involved in the construction of MaDiN have a broad experience in the occasional use of the Internet (see Weigand 2000), but they have not as yet had any experience with virtual lectures. It seemed to be a convenient step to concentrate initially on the second aspect of Internet usage in our lectures.

2.3 Web-based Course Tools

There are some web-based mathematics courses or modules on the web (e. g. "calculus and mathematics"[8], "Interactive Real Analysis"[9], "The Geomaths Front Page"[10], "The Math-Kit"[11], "Mathe-Online Wien"[12], "Mathematik online Flensburg[13], "Mathe-Prisma"[14]), and there are also some supporting materials for

[8] http://www-cm.math.uiuc.edu/
[9] http://www.shu.edu/projects/reals/index.html
[10] http://www.ucl.ac.uk/Mathematics/geomath/frontpage.html
[11] http://ima-www.informatik.uni-hamburg.de/Research/Math-Kit/math-kit.html
[12] http://www.mathe-online.at/
[13] http://www.uni-flensburg.de/mathe/zero/zero.html
[14] http://www.matheprisma.uni-wuppertal.de/

special courses in mathematics education (e. g. University of Giessen[15]). Our goal was to design and evaluate a teaching and learning system for all courses in mathematics education.

To create an Internet-based system, there is a large variety of web-based course tools available, like CyberProf[16], Asymetrix Toolbook[17] or WebCT[18]. These software tools are universal tools for designing Internet-based lectures, but they didn't match our requirements for a course for university mathematics teacher students. Within the frame of our project, we had the vision of an electronic workroom with a desktop and bookcases, which gave students easy access to the contents of the course. We wanted a web-based system, which allowed the students a lot of interaction and activities in geometry, algebra, calculus and stochastics; we wanted a system which provided the lecturer with materials for his lecture, and we wanted a "recorder", which recorded the web-pages which the lecturer visited during his lecture and which could be replayed by the students after the lecture. Additionally, the existing software tools didn't match our ideas in a technical sense. We did not only want a web-based version, but also a CD-version of our system. Since our contents are developed at different universities, we wanted to integrate units and modules from different university servers into one teaching unit, and we wanted to construct a system that would be open for future extensions. All these considerations led us to construct our own web-based system. However, we will not be referring to technical issues in this article.

2.4 Learning Mathematics via the Internet

Despite the huge number of Internet pages in the area of mathematics, very little is known whether and how these pages support the learning of mathematics. There are only a few empirical studies about this crucial didactical question. There are studies which noticed an increased students' involvement in collaborative learning (e. g. Swets 1997), others emphasized the new challenges for the students (basic mathematical skills and computer literacy) while working with the Internet (e. g. Gerber and Schuell 1998, Clark et al. 1998) or the advantages of distance learning (Carswell, L. et al., 2000; Grey, K. a. Xiaoli, H. C., 2000). Waterson and Smith (2002) developed a "layered model for problem assistance" in their online-courses.

Weigand (2000) used the programme WebCT in a semester course "Computers in Mathematics Education" for 150 students to provide the students with Internet materials, especially Internet-based lecture notes, exercises, an electronic discussion panel and an internal course email communication system. The evaluation of this course showed two interesting outcomes. We can categorize the students into two main groups: one group embraced the new opportunities while the other almost refused to work with them. This classification into two groups has been shown within

[15] http://www.uni-giessen.de/math-didaktik/studium.htm
[16] Refer to: www.etb.uiuc.edu/cyberprof/music/199T/index.html
[17] Refer to: www.asymetrix.com/products/
[18] Refer to: www.webct.com

all of the activities in this course, within the participation in the discussion panel, the email discussion and the project work. The good students (according to the results of the final test) embraced the activities more widely than the other students. The well-known fact that additional resources are of more concern to good students than to weaker students was supported in this study. At the end of the semester, the students had to pass a written final test. However, the results of the Internet-supported course were not as good as in the previous years when traditional learning methods had been used, and the Internet-supported course did not contribute to better results in the written examination. To see the positive effects of the course, it is necessary to look beyond the results achieved in the final examination: getting acquainted with the possibilities and typical problems of using new technologies in lessons, being involved in team work, creating web-based didactical materials and getting to know new technologies as a communication tool.

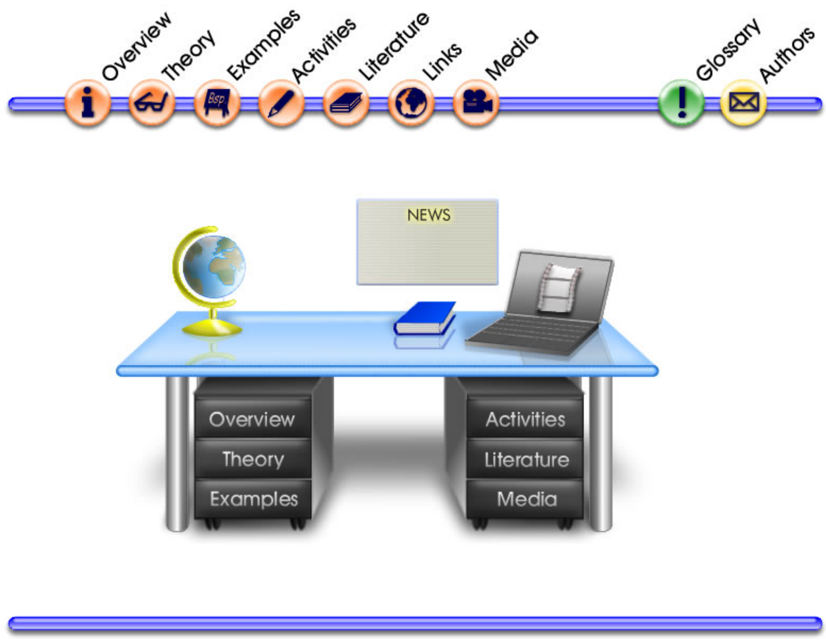
Based on all of these experiences, we launched the project MaDiN.

3. The Construction Ideas of MaDiN

3.1 The Desktop of the Course "Didactics of Geometry"

In the following we refer to the field "Didactics of Geometry" which is divided into different modules:

- Proofs and argumentation
- Concept learning
- Problem solving
- Constructions
- Plane geometry in class 5/6
- Space geometry in class 5/6
- Transformations
- Trigonometry



We therefore have modules which are based on *process goals* and those which are based on *content goals*. Each module has the same structure or elements: Overview, Theory, Literature, (School-) Examples, (Student-) Activities, Media. We use the desktop-metaphor to give the learner the feeling of a familiar surrounding.

3.2 Principles of the Web Design

The design of our pages is based on the following few principles:

- **The desktop-metaphor**: every module and every sub-module starts with a desktop, which always has the same structure, popping up on the screen;
- **Three columns layout**: the information representing the content of a module is arranged in three columns: Orientation buttons – Texts – Materials;
- **Windows overlay:** an effect of depth is achieved by pop-up-windows on the screen. These windows lie "above" all windows and push special information into the foreground.
- **Scrolling**: we aimed to avoid scrolling and therefore minimized the length of the texts. While writing the text, we always referred to one of Albert Einstein's quotes: "*Everything has to be made as easy as possible, but not easier!*"

3.3 Comparing the Internet with a Book

Compared with a book, we would expect a number of advantages of the Internet-based knowledge-base. In particular we have the possibility of:

- A permanent update of the pages with new and current contents; especially a permanent update with authentic materials, which gives students a feeling of working within the frame of "up-to-date" circumstances;
- Availability during the lectures (if there is an Internet access);
- Permanent accessibility (if you have an Internet access);
- Video-based explanations of hand-oriented activities;
- Explaining problems and their solutions on different levels;
- Providing interactive tools and experiments with real-world models.

Due to the use of new media (e. g. videos, downloads) and the appropriateness of hypertext (HTML), it is necessary to provide the students with clear structures, so they can easily organize their studies on their own without getting lost.

4. Research Questions

Within the frame of the MaDiN project, we are especially interested in the following questions:

1. Do the students accept the system? How does the learner navigate while working with the system? How does he work with the system during the semester?

2. How does the style of the lecture change if the MaDiN system is integrated into the lecture on a regular basis? Does the system influence the contents and/or the way the contents are presented?
3. Do the students change the way they take part in the lecture and how they learn the contents of the course? Do the students present their – weekly given – exercises in a new way?
4. How does the MaDiN-system influence the students' understanding of the contents that have been affected by the MaDiN system? Is there any improvement or at least a change in the way students understand the contents? Is there any influence on the *didactical attitude* or the *students' view of the contents* or their *mathematical belief*?

5. Evaluation

In general two categories of evaluation are distinguished:

- A *formative evaluation*, monitoring or process evaluation which is conducted parallel to the development of the system. The result of the evaluation immediately influences the construction of the system.
- A *summative, cumulative evaluation* or product evaluation will be made when the system is ready and can be used and evaluated as a whole (we will be doing this in the next semester).

5.1 First Formative Evaluation

In a pilot-study, students were given a special problem and they were told to use the system for the solution of this problem. The session was videotaped. After having worked with the system for nearly one hour, they had to answer a questionnaire. Their next task was to do a sketch or a graph of the linked modules and they had to give a first estimation of the system. We got a lot of detailed hints about navigation problems, clarity and lack of clarity of the texts and contents that were missing.

5.2 Second Formative Evaluation

We integrated the system into the regular course „Didactics of Geometry" in this winter semester 2002/03. We used different methods for the evaluation of the course. We created "log-files" of each user. These files told us how long the user was logged into the system and what pages he had read. We received written texts from the students and conducted interviews with them. They also had to do weekly exercises which were based on the system, and the final exam was taken in a computer lab, because the students were allowed to use the MaDiN system (and the whole Internet).

The first results of this second formative evaluation will be available at the beginning of February 2003. We might be able to report about some results of our investigation at the CERME3 conference.

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