MATHEMATICAL LITERACY IN HIGHER EDUCATION: ATTRACTING WOMEN TO ENGINEERING PROFESSIONS BY USING ICT

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The engineering profession still is a male domain. Many attempts to change this isolation and to call women into the profession failed. Neither the study conditions nor the social recognition were experienced as adequate for women. The focus on the development of deeper understanding, explicit connectedness, comprehension and social concern are considered as major characteristics that strongly support women's participation and interest in mathematics and the engineering profession. A project at the Technical University of Berlin (TUB) in collaboration with five other Technological Universities, "Multimedia-aided interactive mathematics education for engineers," aims at trying to integrate strongly learner-oriented components into the university studies by using modern ICT. It should serve to discuss the issue of "women and technology".

MATHEMATICAL LITERACY FOR HIGHER EDUCATION

The growing influence of mathematics and technology on society does increasingly require aims of mathematics education for users of mathematics to be re-thought. What is needed today are more flexible, more analytical and abstract problem solvers. In particular, the present mathematical teaching approaches for engineers need to be complemented or even replaced by an approach that provides and emphasises analyses and debates about what mathematical structures and processes mean, both in their own terms, and when they form a technological basis on which 'civilisation conducts its affairs'. And a different kind of teaching methods is required to promote and sustain such an approach to teach 'Mathematical Literacy' (Keitel 1997, Jablonka 2003).

The development of higher education from an elite orientation to a mass education has lead to the perception of university teaching as a social burden neglecting that education is a public task and service. Universities have reacted to the phenomenon of mass education with strong guidelines and regulations for teaching, with schooling mechanisms and an increasing amount of selection modes. The traditional ways of mass learning, mostly passive listening to lectures or presentations in anonymous surroundings which do not support collective activities or to pursue individual interests and perspectives, create a future intelligentsia which is lacking in self-consciousness and critical reflection and is not able to self-organise continuous studying. Although students might have acquired a big amount of "knowledge at disposal" - algorithms and procedures, they lack in "orienting knowledge", knowledge to evaluate and judge competently and to survey and predict outcomes and certain results gained by machines. Mass education also lead to the separation of teaching and research and so contributed to further loss of social recognition.

The critique of university teaching firstly referred to the failures in producing a certain quantity of well-educated scientists or engineers, and later questioned the quality of teaching and the content taught. Although modern information technology has rendered

much of the teaching content and organisation as outdated and ridiculous, changes in methods and content have started much too late and too slowly, because the lack of social recognition has de-motivated university teachers who can gain more recognition by research results than by teaching success.

About 30 years ago a big campaign aimed at calling women into engineering professions failed in providing them appropriate study conditions and social recognition in the profession. Today, investigations on competencies that are needed in the practical fields of engineering show that for modern engineers, the traditionally provided professional knowledge-base is insufficient. What is demanded as key qualifications are described as the "ability to reasonably and critically use analytical methods and procedures", the "ability to abstract-logical thinking", the "ability to undertake continuous, self-organised learning", and also strong connections to, and evaluative competencies for, the application or use of mathematics in engineering problems in the various fields of practice.

This substantial change of the professional image of engineers is partly caused by the new information and communication technologies, partly by new insight into effective learning in higher education. Today, on the one hand, it is necessary for engineers to be able to use all kinds of new technologies in a reasonable and meaningful way, and, on the other hand, to adequately and competently interpret the provided results and search for alternatives. This does not ask for mere computational skills or meaningless practice in all kinds of modelling, but mainly for mathematical understanding and arguing: to understand how the new tools can be intelligently and appropriately applied, and an advanced intellectual meta-knowledge: Mathematical literacy for engineers (see also Keitel, Kotzmann & Skovsmose, 1993, Gellert, Jablonka, Keitel 2001). Not the amount of content, but its exemplary function for self-directed learning is important. Besides content aspects, reform activities aim at the improvement of conditions to learn and study at the university, and to end the inefficient dictate- and repetition manner of university lectures and the memorising in assessment. They should intend to (re)establish and reinforce independent working behaviour of students and to create an increasing ability to study in a self-organised and autonomous way by using texts and materials as means for development of insight by communication. WWW and Internet information and telecommunication on various levels foster this communication as well as the autonomous and collective work on problems.

One major critique from the part of women that persisted for a long time could be matched as well. As gender studies have shown, it is mainly the lack of understanding and justification provided, the abundance of disconnected meaningless algorithms and rules, and the lack of sense-building that hinder women to pursue studies in engineering sciences, technology or mathematics. The focus on the development of deeper understanding, explicit connectedness, comprehension and social concern are considered as major characteristics that strongly support women's participation and interest in mathematics and the engineering profession. While male students are more willing to constrain themselves on accepting just rules and trial-and-error-strategies, getting answers about "how to do" instead of "why to do it", women need to understand mathematical work in-depth, and are predisposed to question why methods work, where they come from and how they relate to the wider body of mathematics and social

conditions. (Boaler 1998, Keitel 1999) Otherwise, they most likely resign from mathematics and engineering studies. A project at the Technical University of Berlin (TUB) in collaboration with five other Technological Universities in Europe ("Multimedia-aided interactive mathematics education for engineers") aims at trying to integrate strongly learner-oriented components into the university studies by using modern ICT. It should serve to discuss the issue of "women and technology" as one clear goal is to meet the needs of women.

"MULTIMEDIA-AIDED INTERACTIVE MATHEMATICS EDUCATION FOR ENGINEERS"

Technology should not be used as a replacement for basic understanding and intuition, but its dynamic character can be used to independently explore and experiment with concepts and classes of objects; the boundaries of the mathematical landscape should constantly be transformed in the teaching and learning process.

The following components of an organisation of new teaching modules include:

- a module for preparing students to study mathematics for engineers, i.e. restructuring school math experiences and generalising previous knowledge;
- a module of a dynamic lecture as a knowledge base and a developmental script to be complemented and enriched by students;
- a testing module for self-assessment and continuous evaluation;
- a module for interactively training of problem-solving in mathematics and mathematical modelling to link lecture, exercises and tutorials;
- a module for interactively designing a "mathematical dictionary for engineers" by students and tutors in the Internet;
- an Internet communication forum with modules for orientation, for administration and adaptation with respect to individual purposes, information, communication and controlling that complements the teaching modules and facilitates the use of the whole range of the communicative offers of IT.

This multimedia-project stands for a fundamental re-determination and restructuring of the contents and methods of mathematics education for engineers, and in particular for revisiting the function and specific roles of the regular teaching parts used there. It has been designed in reaction to the well-known critique on the "service-courses" at the universities specially offered to engineers by mathematics departments that describe the service as inefficient, overburdened, not understandable, obscure and meaningless, hated by students and perceived as selection means, in particular by women.

It is hoped that by modern information technology universities have means to cope with the problems of mass higher education in a more student-oriented, motivating and attractive way, and to provide new means for autonomous learning more satisfying for students and teachers. The components of the Internet-module-system contribute to re-establish the accountability and responsibility of the university teachers by renewing the distribution of the function of the different teaching parts (Seiler & Jeschke, 1999, TUB et al., 2000). The network of the preparing module (providing mathematical pre-knowledge, meta-structures and survey information) with the interactive training module

and the interactive dictionary "Mathematics for engineers" create a forum for communication independently of constraints in space and time.

One major focus of the project aims at attracting women into engineering, and therefore carefully follows the course of study of those female students who actively engage in the project. It is visible already now that women prefer the new teaching style and the various communication arenas offered by the project. They enthusiastically accept the broader possibilities to participate in independently studying and the various learning offers, however the male occupation with technological playgrounds sometimes also distract them from the activities offered by the project. A more updated account will be provided and discussed in the forum.

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