2006-1318: OVERCOMING THE GENDER GAP: NEW CONCEPTS OF STUDY IN TECHNOLOGICAL AREAS

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Overcoming the Gender Gap:
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Abstract

Despite extensive social changes and intensive political efforts to establish equal opportunities, women are still a minority in the fields of natural science and technology studies, as well as in the related professional fields.

The causes for this female "technical abstinence" discussed in literature can be divided into five areas, all highly interlocked and interconnected: the attitude of society, pre-academic education, differences in the access to technology as well as in self-evaluation and finally the image of technological studies. In this talk we concentrate on the latter point and discuss how technology related studies can be designed in order to match female interests.

While it is necessary to reform existing curricula, a second, no less relevant problem has to be to considered. Changes in technology-related studies have to be *communicated* quickly to potentially interested parties which poses a problem in itself: prejudice and the perceived technocratic image are so deeply rooted that modifications and modernizations are often barely noticed. Modernization of these studies should therefore be accompanied by the development of completely new models for technology-oriented studies explicitly addressing the interests of women, in particular concerning inter- and multidisciplinary aspects.

The project GENESIS, located at Technische Universität Berlin, funded by the European Social Fund, is developing several models of co-educative, gender-sensitive model-courses within the three major areas of natural sciences, computer sciences and engineering. These courses and their underlying concepts will be presented in this talk.

1. Introduction: The Image of Technological Studies

A lack diversity in technical conception and development reduces the potential of ideas and innovation within a society, as well as the quality of products, resulting in a loss of competitiveness for a business. For companies, the absence of women in the technical fields amplifies another problem: the long and medium-term demand for qualified specialists is increasing and can no longer be satisfied by men alone. Technical studies are connected to a disadvantageous image that completely conflicts with feminine preferences and approaches and keeps young women, and increasingly, even young men away[13].

- **Technocratic Image:**
  Technology oriented studies often show an unattractive image of engineering – technical theory and technical implementation stressed as a means to an end – that disregards the social relevance and individual perception. The result is often the impression of a soulless technology as a means to an end, instead of matters of beauty and fascination. That poses less of a problem for men, who, due to a certain passion for technology within

themselves, decide on technical studies of their own free will. However, for many women - to whom pure technology is not at all fascinating – technical education is more valuable when it has multilateral relevance.

- **"Absence" of Social Relevance:**
  When women do study a technical discipline or natural science, they mostly wish to study something that is socially meaningful: women study informatics because they would like to work in the field of environmental protection, in aeronautics or in medical engineering. They try to link their interest in informatics with other areas, which have rather stronger social context.[9] The traditional engineering studies do not deserve this claim; therefore, it is not surprising that the ratio of women is at its lowest in the classical core areas of mechanical and electrical engineering, while still comparatively high in the hybrid studies of engineering science such as: environmental technology, media oriented computer science or industrial engineering and management.[2]

- **Absence of Inter- and Multi-disciplinarity:**
  The lamented present lack of inter- and multi-disciplinarity in school curricula continues into many engineering studies: there are no multidisciplinary contexts, broad views or historical references. The rather broad interest of women is directly opposed by a unilateral, outmoded learning/training program which is not only unattractive to women, but also bypasses an actual demand of modern education: the complexity of the global market, the social reference, economical objectives as well as the ecological boundaries call for more comprehensive and integrated thought and action, which has to be mirrored in interdisciplinary approaches.

- **Disregard of "Social Skills":**
  A similar discrepancy can be noted concerning the social skills. Even though commerce and industry constantly emphasize the capacity for team work, communication skills, knowledge of foreign languages as vital qualification, the adequate and necessary changes in curricula are still due.[1] The disregard for social skills in education poses a grave problem in two aspects: first, women consider social contact an important part of their studies. Second, the fields of studies requiring skills not commonly associated with women (and often even considered to be a personal weakness by women themselves) carry higher prestige than those where women have shown particularly high social competence.

- **Problem of Perception and Knowledge Transfer:**
  Engineering courses traditionally suffer from problems in perception and teaching.[1] The prejudice is so deeply rooted that the modifications and modernizations are also often barely noticed. It seems that women have developed an interest in rather new *hyphen-computer-science studies* (media informatics, medical informatics) or *hyphen-engineering- studies* (environmental technology, medical engineering, industrial engineering and management). Apparently, very conspicuous measures like the nomenclature of the studies are essential to convincingly convey inter-disciplinarity and the practical application of a field of studies.[12]

- **Inadequate Motivation Strategies:**
  Finally, many inadequate or inappropriate motivation strategies are used in the effort of trying to inspire women to pursue a study of Engineering sciences; for example, one strategy often used to try to overcome the fear of the unknown, is the suggestion that "everything is, indeed, very easy". Leaving aside the reasonable doubt that an intelligent woman would feel particularly addressed by such an argument it should be obvious that such approaches can only inhibit the development of curiosity, the *main* prerequisite for creating a desire to actually understand and help to shape technology.[10]

It is important to emphasize that technological oriented studies are not per se less interesting for women, but their motivation, specific interests, learning styles, goals and demands often vary significantly from those of men. The rather broad interests of women are often directly opposed by a unilateral, outmoded, techno-centric learning-/training program which is not only unattractive to women (and to an increasing number of men), but also bypasses an actual demand of modern education and the job market: the complexity of the global market, the social reference, economical objectives as well as the ecological boundaries call for integrated thought and action, which has to be mirrored in interdisciplinary approaches. A change within the curricula towards the support of non-technological basics, such as methods- and system expertise, and social skills would thus not only support the interests of women *and* men but also match the demands of the economy.

2. The GENESIS approach: New Concepts and Models for Technological Studies

Within the project GENESIS we developed several model courses for the areas of Natural Sciences, Engineering and Computer Sciences. All courses are based on a very ambitious theoretical education in the respective areas and a broad variety of possible elective courses which can be combined (with some restrictions e.g. in the course for Natural Sciences) in nearly every possible way. The model-courses all emphasize a thorough mathematical education which reflects the increasing importance of mathematical modeling and simulation in all fields of natural and engineering sciences. Furthermore, Mathematics is known to be an area which, compared to Physics, Chemistry and Engineering, attracts an extremely high number of women, although it generally is also regarded as a rather male discipline. Within the model-courses presented in this article, Mathematics is therefore used as a door opener which should, combined with a broader, multi- and interdisciplinary focus of the courses help attracting more women into technology-oriented studies.

Another aspect that characterizes all courses are project-oriented components where soft skills are explicitly trained. Project-oriented here does not mean that the students simply have to "find the solution by somehow working together", but rather that students learn about time-management solutions, communication strategies, project management and controlling in the first part of the course which they then have to apply within a specific project.

Bachelor & Master of Natural Science

With the course "Bachelor & Master of Natural Science" the Technische Universität Berlin will

offer a "*studium generale"* of all natural sciences. Since one of the main characteristics of *all* areas within Natural Sciences is the close connection between theory and experiment, these two working methods also form the basis of the courses for the Bachelor in Natural Sciences. The theoretical foundation of the courses is formed by courses in higher Mathematics and several semesters in Computer Sciences, which is also increasing in importance in Physics, Chemistry and Biology. Another course mandatory course will be experimental physics, which provides the students with the methodology used when arranging and conducting experiments no matter what the specific area of research may be.

Two elective courses offer the opportunity to specialize in one or two areas selected from Mathematics, Physics, Biology, Chemistry and Computer Sciences. These two courses may be chosen and combined observing only one restriction: one of the chosen courses has to come from a more experimental field. This approach may serve as a back door for those students (especially women) who are not completely sure about what area of natural sciences is most appealing to them, often causing them to "default" to courses like Biology and Chemistry. Furthermore, these students tend to pursue a career in teaching, not as a researcher, later on.

The structure of these studies with its multidisciplinary contents derived from Mathematics, Physics, Biology, Chemistry and Computer Sciences, are furthermore especially directed towards the preferences of women. One potential problem of these courses may arise from the strong experimental component of the studies. Due to their socialization, women often underestimate their abilities[7] and do not possess the same degree of experience in experimentation as men. As mentioned above, experiment and theory are intrinsically interconnected in the Natural Sciences. As a result, it is neither possible nor desirable to design courses within this area without an experimental component. What can and should be done is to make the connections between theory and experiment more obvious ("carrot and stick") and also offer additional experimental possibilities, as e.g. virtual laboratories.

The Bachelor & Master of Natural Science can additionally serve as a basis for a general modularization of the courses in e.g. Physics, where the ratio of women is extremely low. As one example we developed a course for the studies of Astrophysics which traditionally is an area of Physics women generally find extremely appealing. This is indicated not only by the high number of women applying for a trainee program at planetaria but also by the amount of women who, during their studies of Physics, choose Astronomy as elective course. This preference is also reflected in the general numbers of women in Physics; 10 % of all Physicists are women while 30 % of all graduates and scientific assistants in Astrophysics are female.

For a more detailed overview of the model course Bachelor & Master of Natural Science see appendices A and B.

Bachelor & Master of Intercultural Engineering

The requirements engineers have to meet have changed dramatically during the past years. A modern engineer is not a Gyro Gearloose anymore, who is sitting in his/her garage developing next-generation computer chips, but rather employees of international companies, working as consultants and offering their often highly specialized knowledge to SMEs. The work of engineers is influencing and changing the world substantially and as their work is often requiring

them to travel all over the globe, engineers are confronted with different nationalities, cultural identities or traditions. Employers therefore deservedly demand that these changes of the job description of engineers are reflected within the education at university. This results in the requirement that a modern engineer no longer only has to be a good technician but also possesses some of the characteristics of a decent diplomat; being able to work in a team, cope with different languages and traditions, offer flexible and adaptable solutions for a problem. Additionally, engineers always have to consider ecological and economical constraints or the geographical and geological environment of a project.

This job description actually fits the demands of women perfectly; the problem inherent in this scenario is becomes apparent when considering the image of the engineer which in general still *is* the one of Gyro Gearloose. Women and increasingly more men cannot identify with this sort of "loner" and it nearly seems impossible to convince them that it does no longer match the work of an engineer. Within GENESIS we therefore developed a completely new course that already suggests a new image of engineers in its very name.

Once again, Mathematics and Computer Sciences provide the majority of the theoretical fundamentals of the course for the Bachelor of Cultural Engineering. The traditional engineering sciences will be taught in courses for Mechanics, Thermodynamics and Electrical Engineering while the modern aspects of engineering will be presented in a special course we call "International and Intercultural aspects of Engineering". It will comprise most of the aspects mentioned above that are relevant for modern engineers. Additionally, students of Intercultural Engineering will have to do a trainee program in a foreign country that has to last at least six months.

Another important aspect of these courses, especially regarding the gender aspect, is the broad variety of elective courses where students can choose from Material Sciences, Logistics, Economics, International Urban Management, etc.

Bachelor & Master of Computer Science & Digital Media

The tendency of female technological abstinence seems to be present not only in the classical engineering fields, like electrical or mechanical engineering, but also in more modern technological fields like computer sciences, which has been developing at an incredible pace over the past three decades and has become a very versatile and challenging academic field and profession. Furthermore, the ability to access and utilize computers and the Internet has become *the* main techno-culture.[3] Competence in the area of information technology becomes an important requirement for an active participation in professional and social life.

The model-course "Bachelor & Master of Computer Science & Digital Media" is strongly geared to the successful concepts and models for a gender-sensitive course for Computer Sciences from Carnegie Mellon University.[9] The courses are based on a profound theoretical education in Mathematics, Numerics and the "classical" Computer Sciences. These areas are supplemented by courses that show how the theoretical models in modern communication and information technology are applied within the broad application area of modern digital media.

3. Summary

Amongst the scientific community, it is widely understood that we must above all understand women's "specific approaches" to technology and actively include them in our educational concepts.[10, 11]

In universities that predominantly concentrate on technology (like the Technische Universität Berlin), the low ratio of female students in engineering studies is particularly noticeable. At the same time, it is *here* at these universities (the TU Berlin), that the majority of the natural and computer scientists, and engineers that live and work in Germany are trained. Therefore, universities play an important role in overcoming the gender gaps in engineering and technology. The awareness of that responsibility is developing only very slowly, though. Especially the German technological universities should, in the future, increasingly prepare themselves for the task of designing their engineering-related courses in such a way as to be equally attractive to both genders.

Various efforts have already been made to increase the number of female students within the technological disciplines. The methods for solving the problem in the different initiatives lead to a classification of both measures: the direct approach proposes that changes are to be made by actively attacking a "problem" and its causes while the indirect approach suggests achieving the goal by further improving on the existing strength of women.

Applied to the low ratio of young women in the technological fields of study this means: one action-plan is characterized by the creation of additional choices and courses, the development of an incentive system, etc. A second plan would rather address female interests and strengths in order to turn them into door openers to an education in the natural and engineering sciences.

In October 2004, the TU Berlin launched a program based on the second approach: GENESIS[5]. With the development of model-courses, the project GENESIS intends to not only convince more women to study engineering and natural sciences (and supervise them optimally within their studies from the beginning to the end), but furthermore tries to support universities in their effort to meet both the demands and needs of industry and science (which do not necessarily match). The overall goal is to assist in creating a new image of technology related studies that motivate men and women to take advantage of the rich career opportunities these areas offer and thus also to ensure that the increasing need for extremely well educated engineers and scientists can be met.

Due to the Bologna declaration[6, 4], European universities provide an ideal surrounding for these types of highly experimental model-courses, since traditional studies are currently modularized into Bachelor and Master courses, which quite naturally implies that the contents of the studies are reviewed and ideally modernized. This holds true especially for universities in Germany, where the structure of education at university has shown to be in large areas not compliant to Bachelor and Master courses. As a result, many German universities have to redesign their contents completely at the moment opening possibilities for the design of very innovative new courses (see e.g. Bielefeld University, Department of Physics). Thus, it is the perfect opportunity to integrate gender-sensitive components into curricula and teaching models.

A Model course for Natural Science – Bachelor

Description

The numbers under the courses indicate the hours per week assigned to the course (e.g. *Mathematics I, 6+2* means 6 hours per week of lectures plus 2 hours of exercises). Additionally, students will be offered exercises in small groups (tutorials), where they will spend at least two additional hours per week.

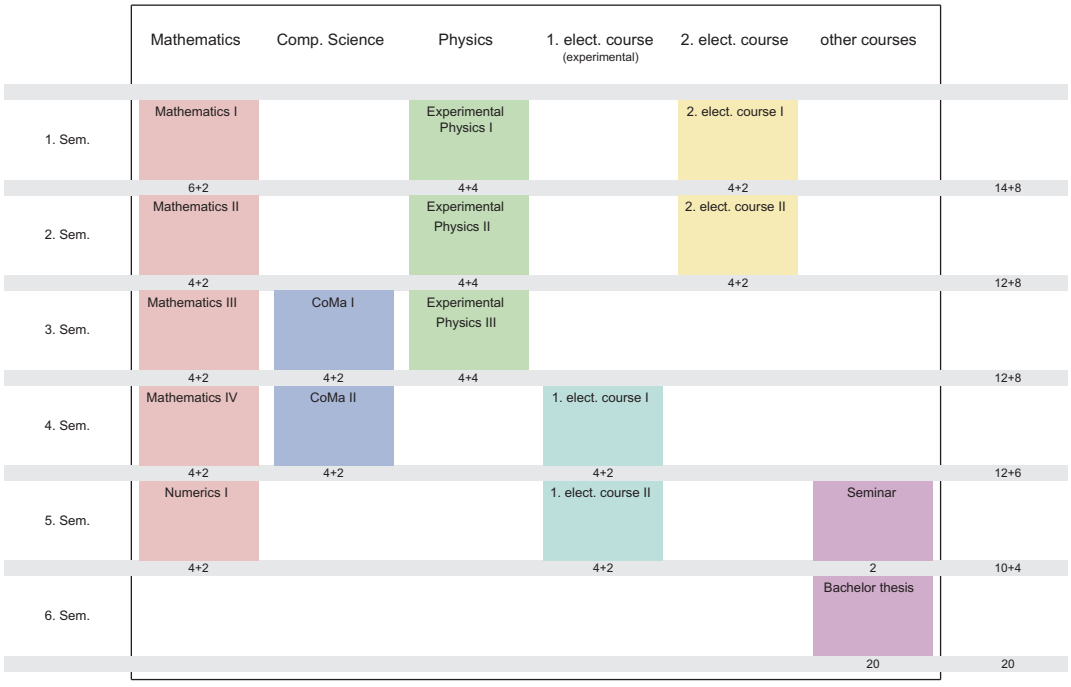

Figure 1. The detailed program for the Bachelor of Natural Science

- **Mathematics I - IV, Numerics**
  In these courses students get the thorough mathematical background, needed for all natural sciences.

- **CoMa**
  CoMa stands for *computer-oriented Mathematics*, teaching a programming language and the usage of computers in science.

- **Experimental Physics**
  Includes both a lecture and a hands-on training where students have to set up experiments that were discussed in the lecture.

- **1st elective course I + II (experimental)**
  The students can choose one of the following courses: Applied Solid State Physics, Applied Chemistry, Applied Astrophysics, Medical Physics or Applied Computer

Sciences.

- **2nd elective course I + II**
  Students can either attend another experimental course from the list above or choose a course in Theoretical Physics, Theoretical Chemistry, Astrophysics, Mathematical Physics and Theoretical Computer Sciences.

- **Bachelor thesis and seminar**
  The subject of both Bachelor thesis and the seminar (where students have to give a talk) should be related to one of the elective courses.

B. Model course for Natural Science - Master

Description

- **Mathematical elective course**
  Students have to select one mathematical oriented course which can be chosen from the whole range of mathematical topics offered.

- **Advanced lab training I + II**
  In these courses students will be trained in advanced experimental techniques.

- **1st and 2nd elective course I + II**
  Students can attend basically every course offered in the fields of advanced Chemistry, Physics, Mathematics or Computer Sciences as a valid choice.

- **Master thesis**
  The master thesis has to be related to one of the elective courses and the student has to present the results of his or her work in a seminar.

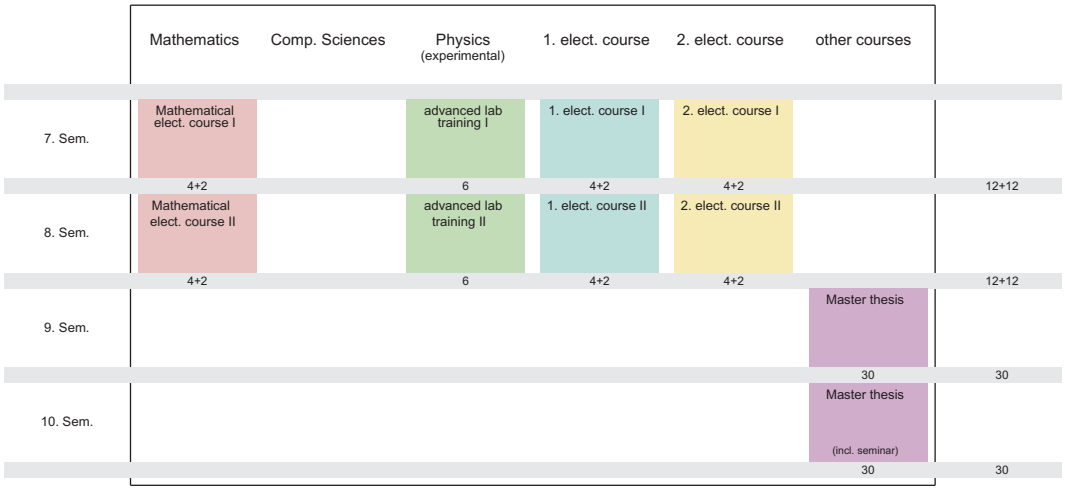

Figure 2. Overview for the courses for the Master of Natural Science

Bibliography

1. Bund-Länder-Kommission. Frauen in den ingeneur- und naturwissenschaftlichen Studiengängen. http://www.blk-bonn.de/papers/heft100.pdf , Mai 2002. Bericht der BLK.
2. S. Collmer. Frauenfreundliche Studiengänge in den Technikwissenschaften -Wunsch oder Wirklichkeit? Ergebnisse eines internationalen Forschungsprojektes. in: Interuniversitäre Koordinationstelle für Frauenforschung und Frauenstudien Graz (Hg.): Auf den Spuren der Frauen in der Technologischen Zivilisation. Graz, 2000.
3. S. Collmer. Wie Gender in die Technik kommt – Computerkompetenz für Frauen (Talk). http://www.frauenakademie.de/veranst/vortrag/img/collmer.pdf , März 2001. Vortrag an der Frauenakademie München.
4. Confederation of EU Rectors Conferences and the Association of European Universities (CRE). The Bologna Declaration on the European space for Education: an explanation. http://europa.eu.int/comm/education/policies/educ/bologna/bologna.pdf .
5. N. Dahlmann, S. Jeschke, F. Körner, L. Oeverdieck, R. Seiler, and E. Zorn. GENESIS – Gendersensitive Virtual Knowledge Spaces for Mathematics and Natural Sciences. Proposal European Social Fund, 2004.
6. European Ministers of Education. The Bologna Declaration of 19 June 1999. http://www.bologna-berlin2003.de/pdf/bologna_declaration.pdf .
7. C. Gunn. Dominant or Different: Gender Issues in Computer Supported Learning. in: JALN, Volume 7, Issue 1. Graz, February 2003.
8. G. Koch, G. Winker. Genderforschung im geschlechterdifferenten Feld der Technik - Perspektiven f¨ur die Gewinnung von Gestaltungskompetenz. in: Stuttgarter Beiträge zur Medienwirtschaft, (8):31–40, 2003.
9. J. Margolis, A. Fisher. Unlocking the Clubhouse: Women in Computing. MIT Press, 2002.
10. H. Schelhowe. Interaktivität der Technologie als Herausforderung an Bildung. Zur Gender-Frage in der Informationsgesellschaft. in: Forschungsinstitut Arbeit, Bildung, Partizipation (FIAB): Jahrbuch Arbeit, Bildung, Kultur, (17):49–55, 1999.
11. C. Schiersmann. Zugangsweisen von Mädchen und Frauen zu den neuen Technologien – eine Bilanz vorliegender Untersuchungsergebnisse. Frauenforschung, Jg. 5, H. 1/2. 1987.
12. B. Schinzel, E. Ruiz Ben. Gendersensitive Gestaltung von Lernmedien und Mediendidaktik: von den Ursachen für ihre Notwendigkeit zu konkreten Checklisten, 2002. Skript zum Vortrag, BMBF-Workshop, Berlin.
13. Many of the problems attributed to technical education that we are about to describe affect male as well as female students. Actually, the interest of men as well as women in technical/engineering science studies is decreasing, we are facing a global “unattractiveness problem”.[8] For years, industrial managers have been increasingly voicing concern about the growing gap between the job specifications and the actual qualifications claimed by the college graduates. Massive deficiencies are especially noticeable among the non-technical, methodical and systematical competencies as well as the soft skills.[2]