The International JOURNAL of INTERDISCIPLINARY SOCIAL SCIENCES

Volume 2, Number 1

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THE INTERNATIONAL JOURNAL OF INTERDISCIPLINARY SOCIAL SCIENCES
http://www.SocialSciences-Journal.com

First published in 2007 in Melbourne, Australia by Common Ground Publishing Pty Ltd
www.CommonGroundPublishing.com.

ISSN: 1833-1882
Publisher Site: http://www.SocialSciences-Journal.com

THE INTERNATIONAL JOURNAL OF INTERDISCIPLINARY SOCIAL SCIENCES is a peer refereed journal. Full papers submitted for publication are refereed by Associate Editors through anonymous referee processes.

Typeset in Common Ground Markup Language using CGCreator multichannel typesetting system
http://www.CommonGroundSoftware.com.

Women Dropouts in Engineering Studies

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Abstract: During the past decades many studies have investigated access barriers for women in the field of engineering studies. However, the analysis of women dropouts in engineering education remains an almost under-investigated research field in Europe. Most studies of dropouts at universities do not consider the situation in engineering studies – especially through a gender lens. The study presented in this paper broadens dropout research by integrating the gender perspective and makes recommendations for the improvement of study conditions for women. By using qualitative research methods, we gained withdrawers' personal explanation constructs, rather than normative knowledge of the reasons for dropping out. The findings of our interviews with 30 female and 10 male withdrawers from technical degrees in particular expose the need to take a closer look at the ambiguity of the learning culture at technical universities. This paper presents five types of withdrawers. Each of them shows specific conflicts caused by mismatches between the characteristics and social practices of the students and the existing learning environment at university. Several specifics of the academic culture of technical degrees are deduced from these mismatches, which cause student attrition among women in particular.

Keywords: Gender Inclusion and Exclusion in Technical Fields, Women Dropout in Engineering Education

Introduction

SINCE THE 1970S, there have been many efforts to achieve equity and full participation of women in the fields of science, technology, and engineering in the European Union. In Germany, increasing rates of women in engineering enrollment have been registered, from 7.7 percent in 1975 to 21.7 percent in 2003[1]. As a consequence of the increasing enrollments up to 2003, a continual increase in the percentage of women graduates can be observed to date. Accordingly, the attrition rates of women in engineering studies were not recognized until a short time ago. In the meantime, enrollment in many engineering majors is stagnating or falling. Against the background of the forecast of a shortage of skilled labor, the topic of attrition in engineering degrees in Germany is becoming increasingly relevant.

At German universities in 2004, approximately every second student withdrew from his or her engineering degree (Heublein & al., 2005). In some subjects this rate is higher than in others. There are some findings indicating that the rate of women students is higher in the figure than the rate of men (Derboven, Winker, & Wolffram, 2006; Meinefeld, 1999), but there are no differentiated statistics in this field. The study of dropouts in engineering education as a whole is an under-investigated research field. There have been many studies on student attrition. However, most of them do not consider the situation of engineering degrees – especially not through a gender lens. Thus, the reasons why at least half of the women break off their degrees after a few semesters have not yet been researched in detail. The dramatically high attrition rate of women students in engineering shows that the question of how women can be attracted to engineering is shortsighted. Interventions aiming at motivating women for technical occupations seem at least questionable if young women who have decided in favor of an engineering subject are disappointed and switch to a more application-oriented institution or a non-technical subject right away. It appears that most of the technical subjects at universities are still unattractive and exclusive. Thus, an equally important question is why so many women students leave their engineering degrees without a qualification and how they can be encouraged to stay on in their degree programs. The objective of our study is therefore to investigate why women withdraw from engineering degrees.

Literature Review

A gendered analysis of dropouts is not normally the focus of studies dealing with student attrition, but is rather carried out peripherally if at all. Out of the German dropout studies in the field of engineering,

[1] Source: Statistical portal VDI: Occupation statistics-university http://194.245.72.99/index4.php?CHOICE=I_1FS&GESAMT=1&FACHBEREICH=Ingenieurwissenschaften+insgesamt&SIZE=600x400 [most recent access: 21.03.2007]

there is only one minor survey focusing on women dropouts in engineering studies, which is part of a larger European study carried out in seven European countries (Pourrat, 2005). This study identifies a number of barriers for women persisting in engineering and science. According to this study, the most important reasons for leaving engineering degrees are loss of academic confidence in a competitive environment and disappointment about the science and engineering curriculum. The latter barrier is also an important one for men. For women, it is often not a lack of academic ability that diverts them from continuing their studies. The lack of confidence developed independently from academic performance seems to be the critical factor. Further barriers were identified in feelings of isolation and intimidation, loss of interest, discouragement by low grades, poor teaching, an unapproachable faculty, and financial problems. Finally, women have a high desire for all kinds of practical work. They want to link theoretical knowledge with practical applications.

The loss of academic confidence in a competitive environment is also one of the main reasons for women dropping out or switching in two US studies (Brainard & Carlin, 2001; Seymour & Hewitt, 1997). Seymour and Hewitt found that there were no significant differences in the factors of high school preparation, ability, or effort expended in the coursework between students who remain and those who switch. However, Brainard and Carlin (2001: 35) found that females with high competence often suffer a decrease in confidence in their academic abilities in math and science. Most women who switch out of engineering do so for reasons such as losing interest in engineering, being attracted by another field, or being discouraged by academic difficulties and perceptions of low grades. The authors conclude that "maintaining a feeling of interest and involvement with coursework, and a sense of doing well academically, and finally the commitment that comes with acceptance into a department appear to be major influences for these women" (ibid.: 36). These factors are much more important than real ability in the women's decision to persist or switch from an engineering or science degree program. Seymour and Hewitt (1997: 274) describe the culture of engineering education, the traditional faculty norms and practices, and deduce that they are counterproductive for reducing the loss of able women: "Young women tend to lose confidence in their ability to 'do science' (regardless of how well they are actually doing) when they have insufficient independence – in their learning styles, decision-making and assessment of their abilities – to survive denial of faculty support or performance interpretation, and refusal of male peer acceptance. Women who persist enter with sufficient independence to adjust quickly to the more impersonal pedagogy, bond to the major through interest and career direction, and develop attitudes and strategies (including alternative avenues of support) that neutralize the effects of male peer hostility."

In all studies dealing with dropouts, the learning environment is one of the most important reasons for students to switch. Two US studies seek to answer the question of why students tend to find scientific degrees 'hard' and 'alienating' (Redish, Saul, & Steinberg, 1998; Tobias, 1990). These studies provide indications of 'alienating' learning environments in engineering. Tobias quotes the lack of communication, explanations, concepts, and overview knowledge, and the dominance of facts and procedures as particular alienation factors. Redish et al. conclude in their study that the introductory physics courses they studied produce a hidden curriculum for learning strategies, which is not consciously intended but rather unintentionally required through the form of teaching. In contrast to the faculty's intentions, the students see rote learning and memorizing as successful learning strategies, which, however, alienate them in the long term. "They [the students] may spend a large amount of time memorizing long lists of uninterpreted facts or performing algorithmic solutions to large numbers of problems without giving them any thought or trying to make sense of them" (Redish et al., 1998). A German study compares the pedagogical structures of science and engineering subjects with varying percentages of women (physics with a low percentage and biology with a high percentage of women representing the sciences, and computer studies with a low percentage and urban planning with a high percentage representing engineering) (Münst, 2005). Its findings indicate that subjects with higher percentages of women students, both in sciences and engineering, have a significantly higher variety of methods and more 'researching teaching structures' than subjects with low percentages of women.

These studies prompt the following questions: what is behind the reasons for dropping out, if the differences in requirements for studying and experiences of studying between students who stay and those who go are either minor or do not exist at all? Is an ideal typical description of attrition processes possible and are there types that are particularly relevant for women or men? Why is it mainly women who have to suffer a loss of confidence? Our assumption is that there is a restricted and rigid learning and performance culture and an impersonal interaction culture in engineering, which influence reasons for dropping out and are of particular significance for women.

The Gender Dropout Project in Engineering Studies

This research project attempts to respond to some of the weaknesses of previous approaches on student attrition in engineering discussed above. In particular, the project attempts to combine a variety of techniques including in-depth interviewing, repertory grid interviews, and an online questionnaire, creating both qualitative and quantitative output. In this way the data creates a provisional framework for the research, and provides an indication of the representativeness of the sample. The qualitative part of the study is already finished and will be the basis for further consideration and discussion on dropouts in engineering studies. In this study, we carried out interviews with 30 former undergraduate women and 10 former undergraduate men who studied engineering at prestigious universities of technology in Germany and who have now withdrawn from the universities. The qualitative study has three primary goals. The first is to obtain a more accurate view of the reasons why the students dropped out. The second goal is to determine what factors influence women's persistence and withdrawal in engineering degrees. And the third goal of the study is to design starting points for reforming the engineering curriculum and the teaching itself in ways that will enhance persistence of women students in engineering. The findings of the qualitative study have informed the online questionnaire, which is active on the Internet at present.

Our research questions in the qualitative study particularly focus on students' experiences in specific situations in their engineering degrees, such as experiences in lectures, practice courses and tutorials. Key guidelines for the interviews were questions regarding which experiences bonded students to their studies or, vice versa, alienated them from them. In this way, we expected to receive results suitable for developing starting points for the design of teaching and learning environments suited to the expectations and intentions of different types of students. These environments should be able to strengthen commitment and attractiveness for these different types. They should also be able to impart academic and professional identity.

Theoretical Approach

Our study builds on the dropout researched carried out by Vincent Tinto, who differentiates between academic and social integration, which students have to achieve to complete their studies successfully (Tinto, 1975). He sees the main reason for student attrition in the difficulties students have with integration into university and their major. He stresses that students have to make integration achievements in both academic and social respects. Whereas social integration is marked by existing friendships and other relationships within the faculty (institutional commitment), academic integration is characterized by the student's grade performance and the self-evaluation of their own intellectual development (goal commitment). In accordance with this twofold process of integration into university life, we distinguish between more academic-related aspects of dropout reasons and more social-related aspects. We have advanced this model through our own theoretical considerations on the interactivity between the student and the university with regard to academic and social practices. These considerations are based on the Pierre Bourdieu's field theory (Bourdieu, 1997). Thus the focus of our research is centered primarily on the social practices of students in the field of technical universities. (Cf. Figure 1)

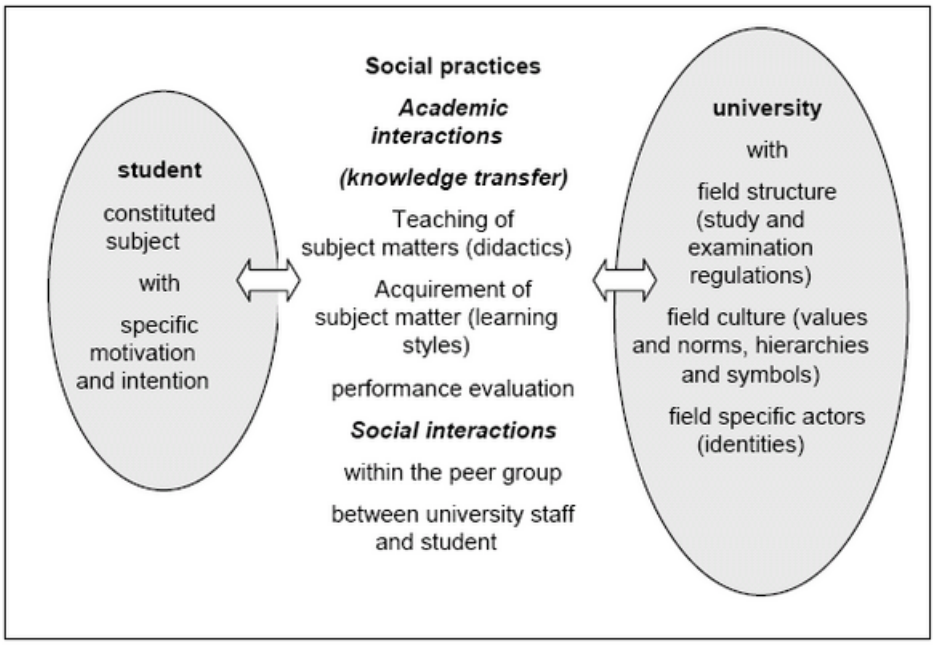

Figure 1: Social Practices and Interaction in the Field of Technical Universities

Methodological Approach

Any study of dropouts in engineering has to consider at least three points. Firstly, the object of research of dropouts opens up two perspectives: the perspective of the student and the perspective of the institution. Secondly, dropping out is not a static event but rather takes place as a process. And thirdly, a study of dropouts with special consideration of women has to tackle the dilemma of an unintentional reproduction of gender stereotypes on the one hand and the unreasonable cancellation of the category "gender" on the other hand (Koch & Winker, 2003). To handle this dilemma, it seems unavoidable for us to work with a relational concept of dropping out that takes the category of 'gender' as its final aspect (Wolffram & Winker, 2004). We aim to discover types of withdrawers on the basis of their intentions for studying engineering, their experiences, and their learning styles. We also want to relate these factors to their achievements in exams and their attitudes, experiences, and interests regarding technology. Not until we have worked out such types of withdrawers can we analyze the gender distribution within each particular type. The gender distribution will be investigated through a subsequent quantitative study.

To address the perspective of the study, our starting point was the description of typical dropout processes from the student perspective. This view is brought to account by means of qualitative interviews with withdrawers. The process character of student attrition is addressed by the choice of theoretical approach discussed in the previous section.

Instruments

We decided in favor of episodic interviews because narrated episodes are a suitable basis for the complex reconstruction of individual reasons and experiences gained. In this way, we expect to gain knowledge about the withdrawers' central experiences and fundamental points of conflict, which were relevant for the decision to leave their engineering degrees. We designed a structured interview form to ensure that the same academic and social situations, which are specific to engineering studies, are addressed and the same information is gathered on each student. These situations can be divided into academic and social situations, following Tinto's dropout model. Academic situations include, for example, experiences in lectures, practice courses, labs, and exams. Social situations concern experiences such as interaction with fellow students, tutors, and other faculty. All these situations have to be narrated by the student, bearing in mind whether they integrated her or him into the engineering degree or whether they fostered the attrition decision. Subsequent to the episodic interview, we employed a computer-supported grid interview to establish the personal constructs of the students and thus the assessments of their own experiences related in the episodes. We assumed that these assessments are actually the relevant factors in the decision-making process and explain why one student leaves the university and another student with the same experiences stays. At the end of the interview, the students had to fill out a questionnaire, which provides us with information about their technical attitudes and interests, and about their

achievement in the final three years of school and in the exams they have already sat.

We then carried out in-depth single case analysis of the interviews and worked out the central conflicts of the withdrawers by the key sentence method. This method tries to keep the shape of the interview and discover the respondent's main messages (Leithäuser & Volmerg, 1988). On the basis of these interview analyses, we have so far found five key logics or mismatches that are central for dropout processes and dropout decisions of students in engineering degrees.

Findings

The following section describes the findings of our qualitative study. Firstly, we will elaborate the types of dropout we found in the interviews. We will then describe the characteristics of the field that cause high dropout rates in engineering degrees.

Types of Student Dropouts

We have found five types of student dropout. We will clarify these types by illustrating the central mismatch, key sentence and individual characteristic.

Type "Don't know how to put the grades into relation"

In the first type we find a mismatch in the assessment logic. That means the students' own logic of self-assessment doesn't fit in with the institutional assessment logic of the engineering sciences. In technical degrees at German universities, assessment is focused on selection and only very few students get good grades. The majority of the students only scrape through their exams. But the self-assessment logic of this type is based on the assessment logic of school, where all pupils who know and apply the subject matter get good grades. Like most other students, these withdrawers get average grades in their exams at university. But they evaluate these grades very poorly and their job-related confidence declines accordingly. The students of this type cannot adapt their logic of assessment from school to the logic of assessment of university. "I always suffer from my average performance" is the key sentence of this type, and at the same time the main dropout reason. These withdrawers do not know how to put their grades into relation. Persons of this type have certain characteristics. They used to be the best at school, so they are not used to getting low grades. Their previous knowledge of technology was not uniform but all in all they are not the typical 'techies' or computer freaks. They take their confidence for studying successfully in a technical field from their very good performance at school. Their intention in studying engineering is often to get a good, safe job. They drop out because they can't bear having poor grades and therefore can't develop job-related confidence.

Type "Don't know how to understand technological phenomena"

The second type comes into conflict with the subject matter. "You only hear the backgrounds to things you don't even know", is their key sentence. This dropout type has many very similar characteristics to the type described above. These withdrawers also had high grades at school and are also more likely to have low levels of technical experience, but they are highly interested in technology. Moreover, they are also confident to study a technical degree successfully due to their school performance, especially in math and physics. However, the main difference between these two types is in the intention. Central for this type is that they want to gain a deep understanding of technical phenomena and artifacts. However, they are mainly trained in mathematical skills in the first four semesters at university. Lecturers at university do not provide the students with a great deal of concepts and overview knowledge. Instead, they teach many isolated facts and mathematical procedures. This type of student cannot develop sufficient ideas about the modes of operation of technological phenomena and artifacts. This is the reason why they suffer, even if they get good grades in their exams. In spite of good grades they cannot develop job-related confidence, because they always have the feeling they do not understand anything.

Type "Don't know how to study"

In the third type we find a mismatch in the study logic. Universities have certain study demands but the only experience students have of learning is from school. They have great problems practicing self-organized study. We find this problem mainly among students who have passed their school exams without major effort. A key sentence of this type is: "I don't know how to study; I passed my school exams without major effort". But self-organized study is not the only problem for these withdrawers. They also want to think as they used to at school, which means they want multidimensional cognitive demands. At school they were used to learning by calculating and by reading. However, at university they have to learn in a one-dimensional way – by means of calculation only. They miss using words and are unwilling or incapable of coming into contact with the technological world solely through calculation.

Type "Don't know what I need the subject matter for"

In the fourth type there is a mismatch in the contents of the curriculum. The university teaches general basics and the students want to learn occupation-related content. In this type we often find students who have a lot of technical experience and a concrete image of their future jobs. "I had a clear occupational

goal. I knew exactly what I wanted to learn at university", is the key sentence for this type. Because they have a clear image of their future working activities they see no sense in learning only general basics. They expect to learn certain content and when they do not get this content they experience university as a waste of time.

Type "Don't know how to integrate"

The main conflict of the last type is the conflict between students' own gender identity and the mainstream gender identities of the field. In our thirty interviews with female dropouts we found this type twice. It is noticeable that both women are not of German nationality. They have their cultural roots in southeastern European countries. They gained very positive impressions of engineering degrees from female friends who studied engineering abroad. Their friends told them they had really nice fellow students and really enjoyed university life. And that was their expectation and, at the same time, their intention in starting their technical degrees. In contrast to the women from the other types, they only had average grades at school and only very limited technical experience and a less specific interest in technology. One remarkable factor is that these women have a high general confidence regarding their performance abilities at university. However, right from the start, they experience that they look different to the other women, and the other women also let them know that they are different. The key sentence of these women is: "I looked totally different to the other women; they all looked a bit like the guys". It follows that they are socially excluded. This is very dramatic in technical degrees, because the students need mutual academic support to get through their exams. Thus, social exclusion causes academic exclusion. Accordingly, they have low grades in most of their courses. But women of this type primarily drop out due to social exclusion.

Field Characteristics Causing Dropouts

From the key mismatches of the dropout types discussed above, we derive certain characteristics in the field of technical degrees that essentially influence dropout decisions.

Perhaps the most important characteristic of technical degrees that causes a central conflict for many students is the fact that the first four semesters are a stage of strong selection. At present, most technical universities in Germany still have no access restrictions. However, these universities nevertheless attempt to attract the most excellent students in the competition for students on the national and international levels. Therefore, a drastic selection process during the first semester has two consequences that are desirable for the university: firstly, a high dropout rate enhances the reputation of the university and secondly, a diploma is only awarded to students who have overcome the selection process and are thus successfully socialized in engineering culture. However, this selection practice also means that most of the students scrape through their exams in the first semesters and do not achieve good grades. The dropout type who "doesn't know how to put his or her grades into relation" in particular is negatively affected by this characteristic.

Another important characteristic of the technical field is that a great deal of previous mathematical and technical knowledge and skills are implicitly demanded for a technical degree, but this previous knowledge is generally not stated explicitly in the universities' information material. This aspect is particularly notable because other degrees do not demand previous specialized knowledge at the beginning of the course (for instance medicine or law). There are some few degrees, such as music and art, where previous knowledge is needed, but in these cases the demands are explicitly communicated and acceptance tests are carried out. This previous knowledge is taken for granted by the university, but not every student is aware of it when commencing a degree, which can cause conflicts for students of the type "I don't know how to understand technology".

The third conflicting characteristic is the fact that technical degrees are separated into two phases. In the first four semesters, the main subject matter taught refers to basic engineering knowledge, and is presented primarily by means of mathematical formulae. Again, students of the type who "don't know how to understand technology" hardly have a chance to access the technical field because they cannot see the technical phenomena behind the mathematical formulae. But the type who "doesn't know how to study" is also affected negatively, because students of this type want to learn in a similar way as they learned at school. These students miss reading-based learning at university. And ultimately, the type who "doesn't know what she or he needs the subject matter for" misses the occupation-related content.

Finally, a very important characteristic of the field is that students very often reach their cognitive boundaries when they try to solve mathematical tasks. That makes learning exclusively alone almost impossible. Students are dependent on the mutual support of their peers. The consequence of this characteristic is that social exclusion among students also triggers academic exclusion. It is obvious that the type who "doesn't know how to integrate" is particularly affected. Moreover, the technical field is particularly closed to certain overtly feminine identities. Some female students, like the two cases we found in our interview sample who felt alien to

the academic culture in engineering, represent the problem of the social exclusion of women with overtly feminine appearances, so-called 'girly girls'.

The social exclusion of women with a 'girly' identity is often perceived as a problem of gender relations between men and women in the field of technology. Men do not acknowledge these young women's technical expertise; instead they take matters into their own hands when they have to work with women in a student team, or they support these women even if they do not need help. That is certainly often the case, but our findings indicate that social exclusion takes place between women with differing female identities as well. It seems that there is a clash between these women in the highly skilled technical field, where the trigger for this clash might be the acknowledgement of academic and technical skills of the female students by the dominant actors within the university. This question needed to be investigated in further-reaching research.

Conclusions

All the aforementioned characteristics are a solid foundation for the development of appropriate interventions to keep young women and men in their degree courses. However, interventions derived from these characteristics also require sensitive handling, because any intervention might destroy positive features of the field. For instance, at first sight, one might think the introduction of admission restrictions could be a suitable intervention for the problem of selection in engineering degrees. This intervention would certainly open up the field for the type of students who have major conflicts with the assessment logic applied at university, because admission restrictions usually mean that only applicants with very good school grades get a place at university, and selection during the course would no longer be necessary. However, this intervention would destroy a traditional occupational field for 'educational climbers' that technical degrees have so far provided.

A consequence of the practice of hidden prerequisites is that students have very varying levels of previous knowledge. Initially, specifically stating and proving this previous knowledge would appear to be an appropriate intervention. However, in such a case we would exclude all those applicants who are interested in technical degrees but do not have the knowledge required. This intervention would also be very problematical, due to the fact that women would be more often affected. In contrast, a suitable intervention might be to offer differentiated courses that consider the differences in the students' previous knowledge. The Carnegie Mellon University in the States has gone this way and has very good experiences with this kind of intervention; in particular they increased the rates of female students to nearly 50 % (Margolis & Fisher, 2002).

Finally, the problem of the social and therefore academic exclusion of 'girly girls' and other students whose identity does not fit in with the mainstream identities of the technical field could be attenuated through stronger academic support by the lecturers, through academic hotlines and virtual student communities. However, this type of academic-oriented intervention would not encourage 'girly girls' to stay on, as they would still feel alien in the academic culture of engineering. This is a strong indicator that an essential change in academic culture is needed if we want to open up the technical field for women and men with multiple interests – in short, open up the field for diversity.

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I studied social science at the Universities of Ratisbon and Hanover and went on researching and teaching at the Universities of Brunswick and Hamburg with focus on higher education and occupation in the field of Engineering, Science and Technology Studies (STS) and gender research. In 2003 I obtained a Dr. phil. at the University of Brunswick, writing my doctorate thesis on "Women in Engineering Studies". I have been a postdoctoral fellow at the Hamburg University of Technology since 2003. I've carried out research about technical attitudes and interests of students in engineering studies. Currently I'm working in a project about female dropouts in engineering studies. Since 2003 I am also working on my postdoctoral lecture qualification dealing with gender constructions in the development and use of technology.

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I studied engineering science at the Hamburg University of Applied Sciences. I have been working at the Hamburg University of Technology since 1987. My researching and teaching activities focused on topics like participation, knowledge management and learning theories. Since March 2003 I have been working in the Working Group "Work-Gender-Technology". Currently I'm researching in our project about female dropouts in engineering studies.

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