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Engineering education - out of the Male Reserve!

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Abstract

In Denmark the discourse on women in engineering and accompanying efforts to attract and recruit more young women to engineering has occurred in waves, the first wave arising in the early 80s and the latest starting around the mid 00s. The impacts of different activities are described.

Recently, the discourse on women in engineering has taken a new turn, linking women in engineering with advantages of diversity and innovation. Another advantage of focusing on recruiting women is that the pool of potential engineering students is broadened.

Center for Engineering Education Research and Development in Denmark (Dansk Center for Ingeniøruddannelse, DACIN) has initiated a project on recruitment of young women to engineering. The project has three phases: Production of raw video material; professional production of information material; information campaigns using the information material produced. The new aspect lies in the fact that producers of raw material are members of the target group, i.e. young women from secondary schools making video films about the lives of female engineering students, respectively female engineers.

A data bank of 8 video films each 2 - 3 hours has been established. Next step has been to select and extract useful material as input to professional production of short video clips, streamers, photos, text etc. to be used in electronic as well as in paper-born format. The paper presents and discusses the project results obtained so far.

Key words: Recruitment; women; engineering; diversity; innovation

1. INTRODUCTION

In many western countries, the lack of women in the field of engineering is seen as a problem from a feminist perspective for the following reasons: 1) it leads to unequal opportunities in society; 2) engineering as a technology-based profession represents power, thus it ought to be shared among all social groups; 3) women are seen as carrying different values, which may contribute to the development of the engineering profession. It is also seen as a problem from a more pragmatic employer's perspective: 4) there is a threatening shortage of engineers in the near future. To this may be added yet another future-oriented perspective: 5) the greater the diversity of staff, especially engineering staff, the greater the innovativeness of companies.

In Denmark, despite liberal doctrines of equal opportunity, there is still a gap between formal and real equality in terms of women's participation in traditionally male-dominated professions, such as engineering.

The precondition for turning out qualified women engineers to the profession is to recruit young women to engineering education. During the last two decades of last century substantial efforts in many western countries were aimed at improving women's representation in engineering education. Two general trends were observed: changing women's views of engineering studies through information and persuasion (mainly in 1980s); changing the education to attract women (since 1990s). During the 21st century renewed interest to recruit women has surfaced and as a result of this interest a project with the aim of recruiting more women to engineering has been launched by the Center for Engineering Education Research and Development in Denmark (DACIN). The

project which takes a new and innovative approach to production of information material for young women in Secondary Schools, is the focus of this paper.

The first section of the paper is this introduction. In the next section a historical overview of the three waves of recruitment of women to engineering in Denmark is presented. The third section discusses the newest discourse on diversity and innovation and links this discourse to the discourse on women in engineering. In the fourth section the DACIN project is described and in the fifth and final section the results obtained so far are presented and discussed, leading to a short conclusion.

2. RECRUITING WOMEN TO ENGINEERING EDUCATION IN DENMARK – A HISTORICAL OVERVIEW

The Danish discourse on how to attract young women to engineering has occurred in waves, first in the early and mid 80s, then in the mid 90s and now again in the last half of the 00s. The discourses have invariably followed in the wake of predictions of a threatening shortage of engineers and have been accompanied by efforts to recruit more women to engineering. This section presents a short historical review of the three waves of recruitment efforts, including a discussion of the short and long term impacts of such efforts.

2.1 The 1980s

The low representation of women in engineering education and jobs first started drawing some attention in the beginning of the 1980s, mainly due to two simultaneous problems in the labour market: An increased unemployment rate in the traditionally female dominated job areas (social welfare, health and education) and a threatening lack of well qualified technical work force, such as, for example, engineers. The remedy used to solve both problems was the so-called “Women into male jobs”-strategy, a strategy which mainly focussed on initiatives to inform and enlighten the women about the educational possibilities and job opportunities within engineering and other technical areas. Thus, a number of short term courses and seminars either aimed at informing and influencing young women or at updating study and career counsellors were held. Thus, the “Women into male jobs”-strategy focussed more on changing the women (by information and persuasion) than changing the engineering education and/or the engineering jobs and the engineering labour market.

The first research projects on women and engineering were carried out [1; 2; 3; 4], the results of which documented that women prefer to work with applied technology rather than with technology 'in isolation', i.e. the technology has to be used to solve problems if women are to take an interest in working with technology. The results also pointed to the necessity of making changes in the educational institutions in order to accommodate women. The following quote is characteristic for the feminist work at that time:

“... increased recruitment of women has to go hand in hand with fundamental changes in the existing conditions in educational institutions and the labour market. ... Thus, we propose the necessity of a double strategy.” (3, p. 280; own translation)

The called for changes of educational system had already to some extent been implemented at Aalborg University (AAU) where the problem-oriented and project-organized group work was introduced from the start in 1974, although not with recruitment of women as a primary concern. This educational change had however not succeeded in attracting more women to the engineering education in Aalborg than what was found at other more traditional engineering educational institutions in Denmark [5].

The research results were not considered nor acted upon during the 1980s and the “Women into male jobs”-strategy remained the dominant approach throughout the decade. This strategy might be said to have been successful – at least seen in a short term perspective: The total ratio of female engineering students at Danish engineering institutions increased from below 10% in 1980 to approximately 25% in 1990, although the female students were very unevenly distributed, with chemical engineering having more than 50% female students and electronics having less than 10% [6]. This success was unfortunately short-lived, as we shall see shortly.

2.2 The 1990s

From 1990 to 1995 the total enrolment to engineering education in Denmark decreased from approximately 4.500 in 1990 to approximately 2.800 in 1995, in spite of the fact that the total number of applicants to higher education increased from 46.255 to 60.189. The ratio of female engineering students decreased from 25% in 1990 to 17% in 1995, thus defying the success of the “Women into male jobs”-strategy [7]. One of the reasons

for this decrease may have been a rather high engineering unemployment rate during the years 1990 – 1994, with the unemployment rate of female engineers being consistently more than twice as high as that of male engineers.

The decrease in the total enrolment led to renewed interest among government, industry and engineering institutions alike in attracting young women to engineering. This time, however, the strategy would take into account the above mentioned research results to some extent. Thus, focus was on creating new educations attractive to women rather than on information and persuasion, i.e. it could be argued that the strategy focussed on changing the education rather than changing the women. During the late 1990s the ratio of female engineering students increased to approximately 23%, but the picture of a very uneven distribution between engineering fields did not change. Today, new educations such as Architecture and design at AAU or Medicine and technology at Technical University of Denmark, have around 50% female students, while important areas such as eg. information technology, electronics and mechanical engineering still have a female ratio of less than 10%.

2.3 The 2000s

The latest wave of discourse on recruiting more engineering students, including more women, has come about during the last half of the 00s and again the motivation driving the efforts is a threatening lack of engineers in the near future. Thus, predictions say that in year 2020 the Danish engineering workforce will be lacking of between 7.000 and 13.000 engineers [8]. A committee has been established by the Ministry of Education and the Ministry of Science, Technology and Innovation with public and private stakeholders to discuss how to attract more students in general and more women in particular. The strategy proposed includes a number of aspects which may indeed appeal to women, such as: More focus on application of technology rather than on technology itself; better pedagogical approaches to teaching and learning; more role models; better branding of engineering jobs, including web based information material about engineering etc. [9]. It is not known to which extent the proposed strategy has resulted in any specific initiatives at individual institutions or at national level, but so far no significant impact on enrolment has been recorded.

With 54% female students in higher education in general, but only 23% among engineering students and with only 11% of Danish engineers being women, engineering remains a male dominated area in a society which otherwise regards itself as gender equal. Thus, to change this situation the need for new and innovative initiatives still exists.

3. DIVERSITY, INNOVATION AND GENDER

A new aspect concerning innovation and diversity has recently been added to the discourse on women and engineering. According to two recent studies on innovation and diversity, increasing the ratio of female engineers would contribute to the achievement of Denmark becoming a more innovative country. Another advantage of focusing on attracting more women to engineering seems to be that at the same time more young men may be attracted, thus considerably broadening the pool of potential engineering students and counteracting the lack of engineers. In this second section the diversity perspective will be discussed and an example will be given of the double positive impact of recruitment campaigns for women.

3.1 Diversity and innovation

The Danish government has as a declared goal that Denmark should become one of the most competitive and innovative countries in the world [10]. An analysis of innovation and diversity in the Nordic countries documents that small and medium sized companies may become more innovative by increasing the diversity of their staff in regard to gender, ethnicity and educational background. Thus, according to the analysis a company may increase its potential for innovation by 110 % by increasing their proportion of female staff from 25 to 40 % [11]. The report on innovation and diversity concludes that there is too little political focus on diversity as a resource, and that there is a need to increase the range of initiatives. While a number of initiatives have already been taken in Denmark to create an enabling framework for innovation, none of them is specifically targeting women [11]. Given that the analysis documents that the proportion of women in high-technological sectors in the Nordic countries is only between 20 - 30 %, there seems to be a great need for initiatives that will result in more women in technological sectors, including engineering.

Furthermore, another study carried out for the Danish Engineering Association documents that engineers are at the forefront in innovation processes in private companies [12]. The threatening lack of engineers may therefore constitute a barrier to the innovativeness of Danish companies and Danish society and the recruitment of more engineering students, including female students, is therefore crucial. Efforts are especially needed within the

male dominated areas of engineering, such as, information technology, electronics, mechanical engineering etc. where the ratio of female engineers is very low.

3.2 Better for women, better for all

An added advantage of aiming specifically at attracting women to engineering is that such efforts may as a side-effect attract more young men. This was demonstrated in a project aimed at attracting more women to computer science and engineering (CSE) at Chalmers University of Technology (CTH), Sweden. It was supported by the Swedish Government through its Council for the Renewal of Undergraduate Education and it enjoyed the support from top management at CTH as well as from Swedish industry. The ‘++’ indicated that the education is “better for women” and thereby “better for all” students, male and female - a statement that seems to be substantiated by the numbers. The 3 fundamental ideas for the D++ programme were: A holistic approach to technology; integration of disciplines; more options. The female participation ratio increased from 5% in 1994 (before the D++ programme) to 16% in 1997. Simultaneously, the total number of applicants for the 110 study places in the CSE programme increased with 40% to 540. The drop-out rate of female students decreased, from 40% in 1994 to 17% in 1997 [13].

The same tendency can be seen when looking at the Danish situation. In figure 1 is shown the enrolment to engineering educations in Denmark, i.e. enrolment to Masters programmes (Civil), Bachelors programmes (Diplom) and total enrolment for the period 1951 to 2004.

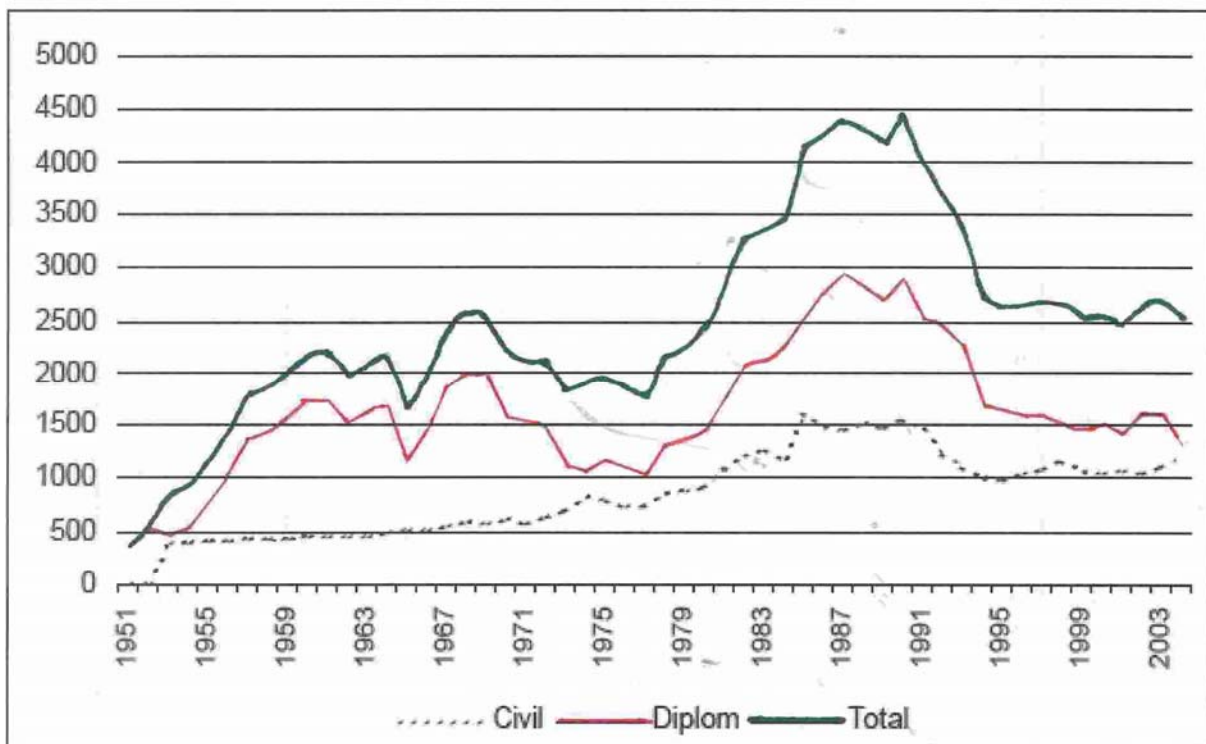


Figure 1: Enrolment to engineering education in Denmark, 1960 - 2004 [8, p. 19]

During the period 1980 to 1990 when a number of initiatives were carried out to attract women, the total enrolment more than doubled while the ratio of female engineering students increased from below 10 % to approximately 25 %, i.e. a non-proportional increase. Similarly, during the decrease from 1990 to 1995 (from app. 4.500 to 2.800) the decrease in female ratio was non-proportionally large, from 25 % to 17 %.

This seems to confirm the hypothesis that attracting more women means attracting more students in general. The reason may be that women represent a non-traditional group of potential engineering education applicants, so by targeting women other non-traditional groups of potential applicants are targeted as well, thus enlarging the total pool of potential applicants.

4. A PROJECT ON RECRUITMENT OF WOMEN

Center for Engineering Education Research and Development in Denmark (Dansk Center for Ingeniøruddannelse, DACIN) was established in June 2007 and has as one of the areas of interest recruitment to engineering. Under the auspices of DACIN a project on recruitment of young women to engineering was initiated in the beginning of 2008. A description of this project is the topic of this third section of the paper, including a description of project actors and stakeholders involved as well as the three project phases.

4.1 Stakeholders

Main focus of the project is the production of information material specifically targeted at young women between 16 and 19 years of age in Secondary Schools (in the following also called 'girls'). It is being implemented in Copenhagen but the aim is to produce nationally applicable material. The project is funded by The Copenhagen University College of Engineering. The main actors are: 8 female students from a local Secondary School; 4 female engineering students and 4 female engineers as role models. Members of the Project Steering Committee (PSC) are: One representative from each of the five engineering institutions involved in DACIN. Other stakeholders include: the Director, Education Guidance Copenhagen; management and teachers from the local Secondary School.

The project plan includes three phases, with the project presently being in the second phase. In the following the first phase is described as implemented rather than as planned, while the second and the third phases are described as planned.

4.2 Phase 1: Production of raw information material

In collaboration with science teachers in the local Secondary School a total of 8 young girls, all female students of mathematics and physics, were identified and taken on as video film producers. Through personal networks as well as networks of female engineers a total of 8 role models were identified, 4 female engineering students and 4 female engineers.

The girls were working in groups of two, each group filming an engineering student and an engineer. The girls had to formulate 5 theses which they would like to explore through interviewing and filming the female engineering students and engineers. Before shooting the video film each group of two girls met with each of the two role models they were going to film, in order to clarify what, why, how, where, and when the filming would take place. Based on the visits to the study and work locations of the two role models a script book was prepared in collaboration with the photographer responsible for the technical handling of the video equipment. A total of 6 photographers were involved in the project. Preparation and actual video shooting took place during weeks 45 - 49 and resulted in 8 video films of 2 - 3 hours each, each with one of the 8 role models playing the leading part.

Since 1980 a great amount of information material aimed at attracting women to engineering has been produced, but as far as the PSC is aware, this is the first time that the young women, who are the main target group of the material, have been actively involved in the production of such material. The rationale is that by involving the young women themselves in the production, chances of getting information material, that will resonate with the young women, are larger than when material is produced by 'wise old' women and/or men believing to know which information the young women need.

4.3 Phase 2: Professional Production of Information Material

Using the 16 - 24 hours of video film as a starting-point a short 10 - 15 minutes informative film about the life of a female engineer will be produced by a professional film producing company. Similarly, 8 shorter films, each 1½ - 2 minutes long, will be produced.

All theses formulated by the girls and all role models will be represented in the final products. Furthermore, the young producers will be invited to appear in the final films for concluding comments and explanations related to their original theses. The films will be divided into smaller sections by text with the most important statements from the role models in relation to the theses of the girls.

Finally, very short video clips, streamers, photos, printed information material, such as GoCards, folders, brochures etc. which can be used in electronic as well as in paper-born format may be produced as part of the project, depending upon resources.

4.4 Phase 3: Using the Information Material

The longer lasting film will be used in connection with 'Open House' arrangements where Secondary School students and their parents are invited to visit engineering institutions. Such visits are being organised annually at all engineering institutions in Denmark as part of public relations initiatives. In connection with the 'Open House' arrangements Secondary School students have the possibility to talk with engineering students of both sexes and they are invited to participate in different types of study activities during the visit.

Furthermore, information meetings will be arranged in Secondary Schools in the local area, inviting not only students, but also teachers, study, and career counselors and parents to such meetings and the film may be shown as part of such meetings. Possibly, the role models may appear as speakers at these meetings as well.

As for the shorter films they will be placed on different web sites of relevance to engineering education, study counseling, educational choice etc. The producers, i.e. the young girls, will furthermore be encouraged to place the films on their Facebook profile and spread them via their Facebook network.

5. RESULTS, DISCUSSION AND CONCLUSION

The project is presently in the second phase where editing of films is taking place. The process of selecting and extracting useful information material from the 16 - 24 hours of raw material is underway and some of the final products may be available at the time of the conference. This last section of the paper will present and discuss the project results obtained so far.

5.1 Results

As mentioned above the girls were asked to formulate some theses about being an engineering student, respectively an engineer, as a basis for interviewing the role models. After the video shooting the girls were asked to reflect on engineering studies and engineering jobs, their own perception before and after the shooting and answer some questions closely related to the theses. So far 4 out of the 8 girls have answered these questions and the results are discussed in the following.

Concerning perceptions of engineering studies the answers are predominantly negative, using words such as: 'tough', 'nerdy', 'hard core', 'much work', 'male dominated' and 'not for girls who are not very smart' but also some positive words, such as: 'exciting', 'varying teaching methods', incl. 'practical work'. With regards to engineering jobs the answers are considerably more positive, with words such as: 'exciting', 'challenging', 'innovation', 'development of ideas', 'construction', 'diversity', 'good salary', 'good possibilities', 'respect from others', 'engineers in high demand' but also some negative words, such as: 'long working hours', 'much work' and 'difficult'.

From the above it seems as if the positive perceptions of engineering work are being overshadowed by negative perceptions and fears of engineering studies. When asked about the main worry in connection with pursuing an engineering study, only one of the four girls believes that an engineering study will be unproblematic, the other three mentioning fears of not being able to cope with the tough studies. The girls were also asked which engineering education they might be interested in, if any. Their responses, such as: medical engineer; design and innovation; export engineer, confirm the preference for studies where technology is mixed with non-technological elements. Also in terms of teaching methodology these girls prefer a mix between self-study and more teacher-controlled teaching, between project-oriented work and individual work; the words 'balance' and 'mix' are used repeatedly.

With regards to engineering jobs the girls answered questions about salary, working hours, work form and traveling. The salary is not the most important factor, although a couple of the girls say that it has to be reasonable in relation to the job. In terms of working hours they all seem to be in favor of a fairly normal working week; only one mentions that if the job is interesting the number of working hours is not important. The girls prefer a mix between project-oriented work and individual work; again the words 'balance' and 'mix' are used. Concerning traveling all of them are moderately or very interested in traveling and 'experiencing the world' as they formulate it, although one of them has some hesitations in connection with establishing a family life sometime in the future.

5.2 Discussion

At this point in time the project is not yet concluded, i.e. no professional information material has been produced and no information meetings have been conducted. Therefore it is difficult to say anything about the impact of the project in terms of future increased recruitment of young women to engineering education. It is the

experience of the authors that for such projects to have a marked impact continuous efforts and ongoing focus is needed over a long period of time. Therefore, results of the project will depend upon whether DACIN will have the capacity to keep up the efforts and the focus and whether the engineering institutions are willing to support DACIN in providing the resources needed. There is no doubt however that engineering needs the young women, not only for the benefit of engineering as such but also for the benefit of society.

According to a recent study the female enrolment rate to Secondary School in Denmark increased from 37,9% in 1982 to 60,1% in 2002. Similarly, the percentage of females attending university increased from 6,3% in 1985 to 19,1% in 2005. The study also showed that the female students, more so than the male students, dare break the social heritage, i.e. they choose educations based on their own interests, rather than following in the footsteps of their parents [14].

Obviously, engineering education could and should benefit from the young women's increased interest in tertiary education and from their courage to break social norms - but in order to do so there is a need for change.

Young people see the choice of education as one of the most important choices of their life, because choosing an education is about choosing an identity. In this process of choice and identity creation, media and role models portrayed in media play a decisive part [15]. Thus, there is a need to change the popular image of engineering by presenting adult role models who offer the young women an opportunity for identification. It is, however, equally important to change the perception of engineering studies as tough and nerdy by changing the contents of engineering studies from 'nerdy' and technology-centered to humanistic and people-centered.

An interesting trend in the university enrolment pattern of recent years is that the interdisciplinary studies combining technical and non-technical elements are popular and in high demand, possibly because young people of today want to combine several disciplines, keeping many doors open, rather than be forced to choose only one [15]. Interestingly, these studies are - as already mentioned above - also the studies that have the highest rate of female students, again confirming women's interest in applied technology and the relation between 'better for women' and 'better for all'. Another interesting tendency among young people of today is a more global outlook, indicating that they are aware that the world is facing some common challenges, such as climate change, environmental degradation and survival of humankind. The young people are aware that they are part of a greater world and that their own happiness is dependent on the wellbeing of this world [15].

Taking these tendencies into account, engineering education, and more specifically the male dominated educations, such as: information technology, electronics, mechanical engineering etc. where the ratio of female engineers is very low, should consider integrating people-centered applications as part of the curriculum, focusing on solutions to major challenges facing the world of today. In other words: Engineering and technology should become part of the solution to the problems of the world rather than be seen as part of the problem.

5.3 Conclusion

The main changes needed in order to substantially increase female enrolment to male dominated engineering educations are: adult role models; change of engineering image; change of engineering curriculum. The DACIN project of recruitment of women to engineering is aimed at achieving the first and partly the second change, but the major change of curriculum needs to be undertaken by the engineering institutions themselves.

With the above described project it is the hope that many more young courageous women will enter engineering studies and will in turn contribute to a change of both the studies and the nature of engineering in general.

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