

TRANSFORMING THE ENGINEERING CURRICULA - GENDER EQUITY IN ENGINEERING IN DENMARK

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ABSTRACT

Due to a dramatic decrease in the enrolment in engineering education in Denmark in the years from 1990 to 1995, a renewed interest in young women as potential engineering students has surfaced in Danish society at large, and more specifically in engineering educational institutions. At the same time critical voices are being raised - from industry as well as from other stakeholders in society - against the traditional engineering curricula as being too technically narrow, failing to embrace development of personal qualifications and interpersonal skills. Also, engineering students are critical in their assessment of the pedagogical aspects of engineering education.

The question is whether these different aspects of criticism can be transformed into a potential for a change towards a broader curriculum within engineering, applying non-traditional pedagogical approaches and including a range of non-technical issues, thereby fulfilling wishes from industry for development of non-technical skills and qualifications while at the same time attracting more women to engineering education and jobs.

In my paper I will give statistics on women in engineering education, give a few examples of the critical voices from industry and from students and take a critical look at recent attempts to increase the proportion of female students in engineering.

ENGINEERING EDUCATION IN DENMARK

According to the Ministry of Education Order no. 681 of 15th July 1996 there are 3 types of engineering educations in Denmark: Master's degree ("civilingeniør", 5 years), Bachelor's degree ("Diplomingeniør", 3½ years) and export engineering ("eksportingeniør", 4½ years). Master's degree courses are offered at the Technical University of Denmark (DtU) and Aalborg University, Faculty of Engineering and Science (AAU). Bachelor's degree courses are offered at DtU. AAU and the existing 5 engineering colleges and the export engineering degree is offered at 2 of the 5 colleges.

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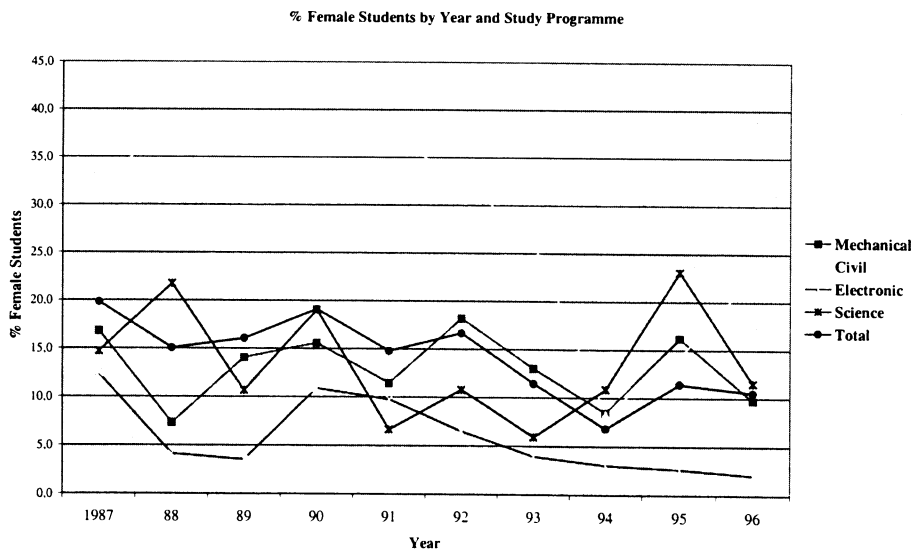
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Over the last 7 years the enrolment to engineering education in Denmark has been decreasing dramatically, falling from 4.521 (of 46.255 applicants for higher education ~ 9.8%) in 1990 to 2.800 (of 60.189 ~ 4.7%) in 1995. (During the same period the enrollment in humanities studies increased from 1.800 (~3.9%) to 5.000 (~8.3%)). A threatening lack of well-qualified engineers is thus the underlying reason that government, industry and engineering schools alike are focusing upon young women as potential engineering students.

STATISTICS

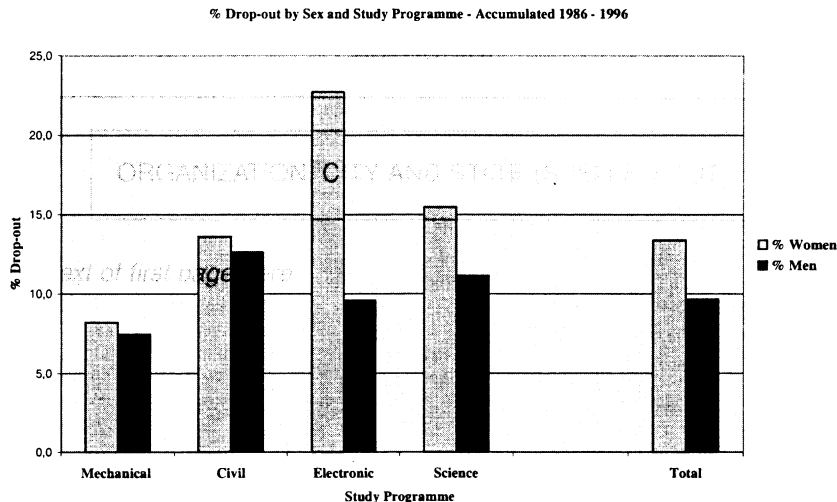
In general it is not easy to obtain reliable gender-segregated **student** statistics from engineering institutions. Therefore **national** statistics are difficult to compile. The overall rate of female engineering students has, however, decreased from approximately 25% in 1990 to approximately 17% in 1995.

With regard to my own institution, AAU, I have compiled slightly more detailed statistics. The statistics shown in figures 1 and 2 do not include the 1st year students at the Basic Study Programme, neither do they include the study programmes Chemical Engineering (which was started in 1993 and has approximately 38% female students) and Land Surveying (which has approximately 39% female students). These two programmes together account for only 9.8% of all students during the years 1986 - 1996, so for reasons of clarity they have been excluded.



Figur 1. Percentage Female Students at Aalborg University, Superstructure Study Programmes only.

Figure 1 shows the percentage of female students by year and study programme. The total percentage of female students has fallen from approximately 20% in 1987 to approximately 10% in 1996. My own area, Electronics, is depressingly low and still decreasing. In figure 2 the drop-out rate by year and study programme is shown. The drop-out rate of female students is consistently higher than that of male students.



Figur 2. *Percentage Drop-out by Sex and Study Programme, Superstructure Study Programmes only.*

Concerning **staff** there are very few female role models among the tenured staff at AAU. In 1996 there were no female Full Professors out of 42 (since then 1 has been employed). There were 22 out of 225 Associate Professors (~ 9.8%) and 10 out of 58 Assistant Professors (~ 17.2%). A recent **national** statistic gives the following figures per 31/12-1996 for higher technical education: 1.9% female Full Professors, 7.2% female Associate Professors and 21.1% female Assistant Professors.

The female engineers constitute approximately 11% of the **professional membership** (>45.000) of Society of Danish Engineers (IDA). There are no recent statistics on **employment** but female engineers are more often than male engineers employed in the public sectors (32% as against 13% in 1993, based upon a small sample of engineers) and they earn less than male engineers, given the same working hours and the same age.

The **unemployment** ratio among female engineers is approximately twice as high as among male engineers. This difference is due to three factors: Firstly, unemployment is higher among the younger graduates (among whom there are more women). Secondly, unemployment is high within those branches that women tend to prefer, i.e. chemical engineering and export engineering. Thirdly, the small and medium sized companies which

constitute a major part of Danish industry tend to be unwilling to employ female engineers due to childbearing and -rearing responsibilities (which still rest more with the mother than with the father).

INDUSTRY ON ENGINEERING QUALIFICATIONS

In this section I will quote a few reports from Danish industry, all pointing to the fact that there is a need for educating engineers with new and broader qualifications. The first report quoted is called "On the Track of the Profiles of Future Engineers - Views on Economics and Management Disciplines in the Basic Engineering Education" by The Danish Academy of Technical Sciences (ATV), June 1997. Extracts are from the English Summary:

"The engineers of tomorrow must still undertake technically advanced tasks and development projects. At the same time, they must become capable of combining technical tasks with non-technical ones, such as production and project management, planning, communication and marketing activities." ([1], page 84)

"... However, every course must include lectures on business economics, investment analysis, project management, organisation, decision-making processes, and communication/negotiation skills. Furthermore, every engineering curriculum must contain at least two to three problem-oriented project works of which financial and managerial aspects form integral parts." ([1], page 85)

The next quote is from the report "Lack of Engineers - A ticking Bomb under the Welfare Society" by The Danish Academy of Technical Sciences (ATV), March 1996. This report was made in response to the threatening lack of engineers. Extracts are from the English Summary:

"...While focussing mainly on quantitative problems, the forecast also reveals a growing concern for engineering qualifications. ...

The report concludes that steps must be taken to improve qualifications and re-increase the flow of students towards the Danish engineering educations..." ([2], page 41).

From the Danish summary a few quotes have been translated:

"Global competition demands elitist engineers

The demand in this situation [ie. with a threatening lack of engineers] is not only more engineers but more engineers with the right professional and personal qualifications....

Also need for soft qualifications

...To develop and market an increasing amount of customer-oriented services are needed systems analysts with conceptual, technological and economic un-

derstanding rather than highly specialised technicians. Further, the communication and presentation skills of engineers are found to be generally insufficient." ([2], page 8).

Criticism raised by students focuses mainly upon the low level of pedagogical qualifications demonstrated by teachers at engineering schools and upon the weak contacts to industry, for teachers as well as for students. Seen in the light of these critical points in engineering education I will now take a closer look at recent initiatives in Denmark.

INITIATIVES TOWARDS INCREASING THE FEMALE PARTICIPATION IN ENGINEERING EDUCATION

Due to the study form at AAU some of the personal skills requested by industry, like project management and communication skills, are already an integrated part of the study. A newly initiated (September 1997) study programme is Architecture & Design which has a gender balance. This programme combines elements of creative design and architecture with more technical elements from civil and construction engineering. In September 1998 a new programme called Information Technology will be launched, combining elements from computer science with elements from humanities and design. Finally, a mentor programme will be started up in Autumn 1998, in an attempt to reduce the drop-out rate among female students. We hope to be able to co-operate with University of Washington in this programme.

At Dtu recently 2 positions as assistant professors in Information Technology have been reserved for women. These 2 women, together with a female associate professor will be making attempts to recruit more women to information technology. Also, a mentor programme with female industry mentors is being established in co-operation with the IDA Women's Committee.

The seven engineering schools are co-operating in the Engineering Educational Co-operative Council (IUS). This council established a **Women's Committee** in 1996. The committee has prepared a report on the barriers to women's participation in engineering, including a catalogue of project proposals. Further, the committee arranged a series of 3 seminars under the title "Women in Engineering - an International Perspective" where Dr. Suzanne Brainard, University of Washington, together with 4 Swedish guest speakers elaborated upon success-stories from their universities. The Women's Committee has now dissolved itself due to lack of funding.

The Society of Danish engineers (IDA) also has a **Women's Committee** which is a policy making body, funded by IDA. Last year the committee celebrated the 100th anniversary of the graduation of the first 2 female engineers in Denmark. In connection with the celebrations a book on the lives of female engineers and a brochure with work profiles of female engineers have been published, and an award named after the first 2 women was instigated. Finally, the committee is co-operating with Dtu on the mentor project mentioned above.

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The last initiative I want to mention is the **CuWaT-project**, an EU-funded project under the Leonardo da Vinci-programme. The outcome of this project is a book, titled "Changing the Curriculum - Changing the Balance?" [3], the main message of which is that there is a need to change the engineering curriculum in order to attract more women and other presently under-represented groups to engineering. The change suggested is a 3-dimensional change: Change of pedagogical approach, change of content and change of the institutional culture.

Change suggested in pedagogical approach is from teacher-centered teaching to student-centered learning, with students being enabled to take responsibility for their own learning. The change in content is towards a more holistic view of technology, including in the technical solution important aspects of for example social, economic, political, cultural and other issues of relevance to the technological problem at hand. The change in culture suggested in the CuWaT-curriculum can best be described as a change towards a diversity management culture where diversity of gender, class, race, ethnicity, age etc. is respected and appreciated as a strength, in the student body as well as in the staff.

The book is aimed at managerial staff who are already motivated to introduce changes to attract more women. It does not prescribe a certain curriculum but raises issues and questions which are important and need to be considered when attempting change. It also contains a number of examples of "good practice" from the partner countries involved in the project.

CONCLUSION

From the above it should be clear that there are a number of initiatives underway in Denmark to attract more women - and more students in general - to engineering. My own preference is for initiatives like the ones described in the CuWaT-curriculum, not only because this kind of changed curriculum - based upon the experiences from the eighties, where many recruitment campaigns were carried out but with only shortlived success - will be the only initiative with a long-lasting impact but also - and more importantly - because I believe that there is a desperate need to change engineering and technological development towards a more socially and ecologically responsible development if (wo)mankind wants to survive long into the next millenium.

REFERENCES

- [1] *"On the Track of the Profiles of Future Engineers - Views on Economics and Management Disciplines in the Basic Engineering Education"*, The Danish Academy of Technical Sciences (ATV), June 1997 (in Danish).
- [2] *"Lack of Engineers - A ticking Bomb under the Welfare Society"*, The Danish Academy of Technical Sciences (ATV), March 1996 (in Danish).

- [3] *“Changing the Curriculum – Changing the balance?”*, a Publication from the CuWaT-project under the Leonardo da Vinci Programme, Contract N/95/1-23P1-CVT, ID:3636.

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