

Women's Role in Engineering

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Young women are encouraged to study engineering and obtain engineering degrees at every level. These women will be a needed addition to the workforce in industry, government, and academia. To serve as role models, the number of female engineering faculty must be increased. The situation in Norway and the United States is discussed.

INTRODUCTION

THE AUTHORS are pleased to have this opportunity to discuss the role of women in engineering. As we look to the year 2000, we note how two nations, one small and one large, examine this critical situation.

THE NEED FOR WOMEN ENGINEERS IN NORWAY

Norwegian women are widely perceived to enjoy equality with men in terms of education, employment, legal protection, social benefits, and political influence. It is true that the employment rate of Nordic women is relatively high, that their rights are assured by law, that they share in well-developed social security systems, and indeed in Norway's most recent government 9 out of 19 members, as well as the leader, were female. Nevertheless, although women's participation in the workforce has risen from 41% in 1980 to 45% in 1988, Norway has a labor market that is still segregated by gender.

There is a high degree of vertical and horizontal segregation and an even stronger concentration of women in a small number of occupations. In Norway men typically choose between a much broader spectrum of studies and occupations than women. Roughly speaking, men choose between 300 different occupations, whereas women limit their choices to 30. The increase in the laborforce participation rate of women during the past 10 years has thus come mainly in occupations that are already female-dominated; only a slight increase has occurred in male-dominated occupations. Natural science, engineering, and technology are the areas with the lowest female participation rate in terms of both education and occupation.

Norway has only 4.2 million inhabitants. If we

look at the percentage of engineers out of the total workforce (2,183,000) we find that male engineers constitute 3% of the workforce, whereas the percentage of women engineers is only 0.3%. There has, however, been a gradual increase in women engineers in recent years from 59,000 (5%) in 1981 to 72,000 (10%) in 1988. And whereas there were no female chief engineers visible in the statistics form for 1981, the percentage of female chief engineers in 1988 was 5% [1]. The official estimates of the need for engineers in the near future is 1500 graduated engineers at Master of Science level ('sivilingeniører') and 3000 at Bachelor of Science level ('ingeniører') per year. These estimates do not say anything specifically as to gender distribution but it has for many years been explicit government policy to increase the number of women in traditionally male-dominated areas of education [2]. The Law on Equality between the sexes, operative in 1975, followed by the Plan of Action for Equality between the sexes both document the broad political agreement on this.

The Norwegian Institute of Technology in Trondheim, which is the largest institution for engineering education in Norway, has set a goal of 40% female engineering students for their institution. They have put considerable effort into achieving this goal. So why is it that the universities and colleges of engineering launch recruitment campaigns and give additional credit points to women on admission, why do we publish leaflets and videos, heavily sponsored by industry, to try and motivate girls into engineering education? The answer is simple: because women are wanted and needed as engineering students, as academic staff in engineering education institutions, and as practicing engineers in industry and public service. Some of the reasons why this is so may be summarized as follows.

Women's qualitative input to engineering and the education of engineers is different from men's. As Samuel C. Florman puts it in *The Civilized Engineer* 'Women bring to engineering a heightened appreciation of the humanities—and of the

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values inherent in humanistic education' [3]. Women students of engineering in Norway want more emphasis put on the 'societal' responsibility of the engineer in the curriculum than their male fellow students [4]. A broader view and an aesthetic and humanistic concern may be obtained by considering important contributions from female engineers. An example of this from everyday life in Norway is that male highway engineers wanted to maximize the road size for the funds available, whereas female highway engineers wanted to ensure adequate pavements for schoolchildren.

Technology and engineering are increasingly affecting our everyday lives, and the threat to our societies, and indeed to our planet, caused by pollution and disturbed environments has become a major concern in Norway. In this situation it is necessary to draw on the resources, initiatives, inventiveness, and positive action capacities of both men and women. Women have to take part in the decision-making that engineers will largely be responsible for in order to redress the environmental imbalance of our planet. It seems as if this tremendous challenge has a special appeal to women. An indication of this can be seen at DTH in Copenhagen, where 60% of the engineering students in the newly established environmental study program are women.

Income from the offshore oil industry, accounting for the Norwegian economic boom in the 1970s and early 1980s, will have to be partly substituted by income from more knowledge-based industries in the future. And here, of course, engineers play a key role. The demographic decline in the number of young people in the 1990s, however, poses a problem: it implies stiff competition among different educational institutions to attract a sufficient number of students. Already, the present recruitment pool for engineering education is almost exhausted, and therefore an enlargement of the recruitment pool is necessary if the demand for engineers is to be met.

Women clearly represent a recruitment potential. The strong tendency for girls to opt out of mathematics and natural sciences in school, and thus disqualify themselves from entry to higher technical education, evolves in an underutilization of a major national resource. This resource has to be tapped in the future. The 'technological illiteracy' of a large part of the female population is neither beneficial to society nor to each individual woman.

THE NEED FOR WOMEN ENGINEERS IN THE U.S.A.

As emphasis is increasingly placed on the technological changes that are creating brand new industries, revising other industries, and making others no longer competitive, there is a continued and growing need for the skills of engineers in the U.S. population [5]. However, during this period of

rapid technological change many studies show that the total number of U.S. citizens in the age group suitable for beginning engineering studies (i.e. 18–24 years old) will decrease from 1980 to the year 2000 by about 20%. With fewer young people available, coupled with the need to maintain an increase in the production of engineering graduates, the engineering schools of the U.S.A. must enroll a larger percentage of those students who enter college education, and the U.S.A. must also increase the number of young people who have the qualifications to enter college. The number of engineering bachelor degrees granted in the U.S.A. began to show a decline in 1987 and continues to do so [6]: 6% fewer engineering degrees were awarded in 1988 than in 1987!

Of special interest is the fact that women have been underrepresented in the engineering population in the U.S.A. for some time. Thus, current data [7] show that only 15% of the total first-level engineering degrees (i.e. Bachelor of Science or equivalent degrees) are awarded to women.

It is clear that demographic trends in the U.S.A. combined with the role of women in U.S. society is such that women engineers are in the minority at a time when U.S. industry has developed a vital need to maintain and increase its supply of engineering talent. Simple calculations indicate a need approximately to double the supply of women engineers in order to maintain a constant supply of engineering graduates (male and female) for the year 2000. Yet, with the current rate of technological developments, the U.S. requirement is such that our aim should be to triple the supply of female engineering graduates.

THE ESSENTIAL ROLE OF FEMALE ENGINEERING FACULTY IN NORWAY

'Perhaps it is more important for women to know people who are engineers than it is to know what engineering is itself.' Pat Durchholz draws this conclusion in her article 'Women in a Man's World: The Female Engineers', based on results from an investigation at the University of Cincinnati in 1976. Other research results point in the same direction. Women need a broader range of role models who can give direct information about occupations, and—most importantly—women need to know what kind of people are to be found in a particular occupation. Persons who may serve as role models are, for example, parents, the natural science teacher and other persons in their most immediate environment.

A survey at the Institute of Technology shows that more than 50% of the female and 34% of the male students were of the opinion that there ought to be more women faculty at the Institute. And the reason they gave was that women faculty would serve as role models for the female students [4]. 'It means a lot to see that women reach so far. It motivates and encourages', was a typical answer to

the survey. Another answer was 'I think women lecturers are better than men. Maybe because in order to reach their position, they needed to be more competent than men.' Women faculty members thus have a significant influence in engineering education as role models.

The situation in primary and secondary school as well as in higher education will briefly be looked into. The majority of mathematics—and natural science—teachers in schools are men, whereas the opposite is true for teachers of languages and aesthetic subjects. At the lower secondary stage, only one-fifth of the mathematics teachers and 16% of natural science teachers are women [7]. What is also characteristic of the situation in Norway is that very few primary and lower secondary school teachers have an educational background in mathematics and natural sciences. This is due to the generally low status of these subjects at the teacher training colleges from where they graduated. (Only about 50 out of 1500 specialize in one of these subjects.) In upper secondary school (general area of study) the situation is good as concerns the teachers' educational background in mathematics and natural sciences. The majority of these teachers are university graduates, and almost 20% of the higher-degree graduates in natural sciences are women. In higher education, at the universities, women constituted 7% of tenured staff in the natural sciences and 1% in technology in 1983. The figures for recruitment personnel were 19% and 7% respectively [9]. At the Institute of Technology in Trondheim, 3.7% of the lecturers were women in 1988. Out of a total of 192 professors, five were female professors (2.6%). At the 16 regional colleges of engineering, 5.8% of the lecturers were women in 1988; at present, only one of the colleges has a woman head.

THE ESSENTIAL ROLE OF FEMALE ENGINEERING FACULTY IN THE U.S.A.

There have been numerous studies of the reasons that young people aspire to various careers. Factors mentioned have been the influences of the parents, relatives, teachers, television, magazines, and others that play a strong role in the early decisions of children about their future careers. Those young people that do enter engineering college and university programs in the U.S.A. are currently faced with an engineering faculty that is predominantly male (90% in 1985). Thus, the female engineering student lacks the role model of the successful female engineering faculty member that she can look up to, admire, and aspire to emulate. The need for role models as a source of continued inspiration and motivation for college and university level students is well known. The retention of female engineering students is just as important as the recruitment.

There are two problems with the lack of female

engineering faculty in the U.S.A. The obvious is that they simply are not there when young female engineering students have a need. The less obvious is that many U.S. engineering educators believe that the shortage of engineering female faculty tends to discourage women who have started their studies towards a career in engineering to continue their studies. The discouragement may be to a point where they transfer out of engineering studies to a program of studies where they feel more comfortable and have female faculty to motivate them.

A large number of female engineering faculty are definitely needed to balance the male dominance of U.S. engineering faculty. This will take time to develop and such improvements have been coming out very slowly. Presently, U.S. engineering faculty are mostly drawn from the group that hold doctorate degrees in engineering. For women this is a small group (6.7% of the total engineering doctorate granted in 1985–86) which is now in great demand not only for engineering faculties but for production and research industries as well. Industry realizes the importance of adding doctorate-level women engineers to their professional staffs. Thus, engineering institutions must take steps to develop and employ female engineering faculty members who can serve as role models for female engineering students to assist the long-term goal of attracting and retaining more women in engineering careers. The need exists for female engineering faculty members, and the universities will find themselves competing with industry for the short supply that is available.

COMMENTS ON THE SITUATION IN NORWAY

As described earlier in this paper, there has been a gradual rise in the number of women engineers in the Norwegian workforce in general and also among tenured staff in higher technical education. A corresponding development naturally has taken place in educational institutions. From 3% female students at the Institute of Technology in Trondheim in 1960, the percentage has increased to 26% in 1988. At the colleges of engineering the rise has been from 10% in 1980 to 23% in 1988.

However, this steady increase of female engineering students reached a peak in 1987–88 and the institutions of higher technical education have seen a gradual decline in female numbers during the past few years. In 1989 women constituted 21% of the new students at the Institute of Technology, and 19% at the colleges of engineering. This decline has occurred despite information measures and recruitment campaigns, school visits by young female engineers and engineering students, and media attention on women in untraditional occupations. (An example of one measure that received quite a lot of attention, nationally and internationally, is the video entitled, *Size 38. A Footnote on Women Engineers.*)

It seems as if young women tend to go back once more to the traditionally female-dominated courses and occupations. After some decades of venturing into male-dominated areas, the trend for women seems to retreat to 'safety' in teacher training, preschool education, and nursing. Economic recession, uncertainty on the labor market, and a relatively high rate of unemployment (5%) may in part explain this shift. At a deeper level, however, it may be that a change in the contents of engineering education, based on a change in underlying values, with more weight on ecology, on societal consequences, and an interdisciplinary approach would attract more women into engineering and engineering education in the future.

COMMENTS ON THE SITUATION IN THE U.S.A.

The situation in the U.S.A. has been reported in numerous publications. An excellent overview has been presented in two issues of *Engineering Education*. A special issue of *Engineering Education* [10] dealt with the supply of engineering talent prepared by the U.S. schools and colleges of engineering over the next several decades. It views the preparation of students in precollege work and thus discusses the entire 'pipeline' of students in the U.S.A. Articles within this 'engineering student pipeline' issue refer specifically to recruiting more women into engineering. The second issue of *Engineering Education* that is of special interest [11] deals with the engineering faculty of the 1990s and beyond. This issue also features articles referring to women faculty in engineering and women in engineering.

It has been emphasized that until now in the U.S.A., 'the role of minorities, women, and people with disabilities in science and engineering has been widely seen only as an equity issue, rather than as a key to future national strength in science and technology' [12].

Detailed statistics about engineering education in the U.S.A. are available from the National Science Foundation. Figure 1, which was obtained from NSF data, illustrates the improvement in the U.S.A. in the numbers of undergraduate women enrolled in engineering followed by the current stagnation. (For reference purposes, data on the Norwegian situation are included.) In view of the lack of current progress on interesting women in an engineering career and the need for women engineers, the Office of Technology Assessment [13] of the United States Congress has recommended that women be provided with special support and intervention. Accordingly, a number of federal programs are giving special attention to encouraging women to study, practice, or teach engineering (e.g. [14]).

Detailed studies of women's role in engineering have been carried out by a number of U.S. professional societies. References [10] and [11] provide a

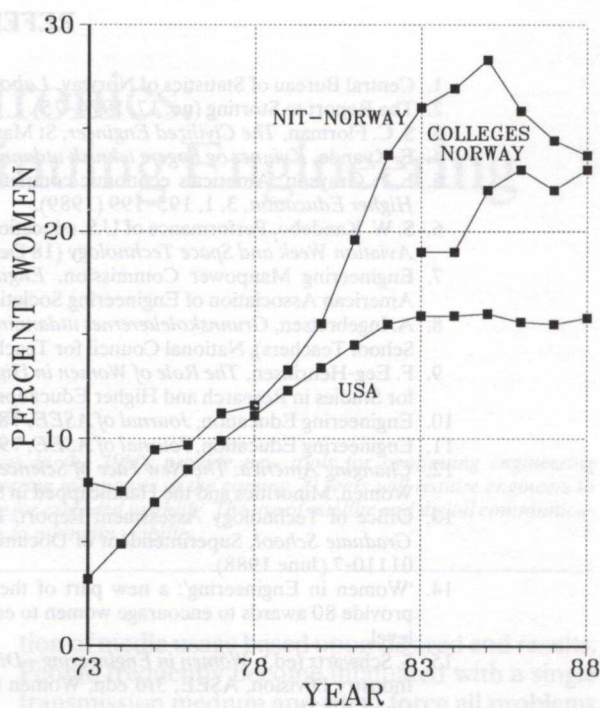


Fig. 1. Undergraduate women enrolled in engineering programs (percent of total enrollment, Fall 1973-1988). (U.S.A. data from NSF; Norway data from Norwegian Institute of Technology and the regional college of engineering.)

number of citations to individuals and groups that are actively involved in women's role in engineering. Reference [15] is a document that has been developed for high school counselors, students, colleges/universities, and others involved directly or indirectly in encouraging qualified and interested women to consider an engineering education. It should be noted that the Society of Women Engineers (345 East 47th Street, New York, NY 10017) is a non-profit organization that was formed in 1950. Its objectives include that of informing young women, their parents, counselors, and the general public of the qualifications and achievements of women engineers and the opportunities open to them.

CONCLUSIONS

The changing times in Norway and the U.S.A. all point to an increased demand for women engineers. The recent and predicted changes reflect the needs for a technologically driven economy coupled with a deep concern and requirement for environmental factors. In order that more females will enter studies for an engineering career and continue those studies, the teaching and attraction of mathematics and science in the primary and secondary schools must be enhanced and more female engineering faculty will be needed in engineering colleges and universities.

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