

The Status of Women in Engineering Education*

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The participation of women in engineering education has been a subject of many engineering education studies. This paper presents an investigation into the status and participation of females in engineering courses in the Faculty of Engineering at Monash University over the last 30 years. The statistical data gathered here indicate that the rate of participation of females in engineering courses at both the undergraduate level is still unsatisfactory. More work is needed throughout the entire education system, beginning at the primary and secondary levels, to increase the entrance number of females in engineering at the tertiary level. For reasons of comparison, the paper also considers the status and participation of females in science disciplines at Monash University.

INTRODUCTION

MINOR CHANGES have been observed in the enrolment of women in engineering courses at Monash University in the last two decades. In the late sixties through to the early eighties, the participation of women in engineering was particularly low; in 1969, for example, the number of women enrolled was less than 1% of the total enrolment in engineering. Since the early eighties, more women have chosen engineering as an option for tertiary education.

While it is gratifying to observe an increase in the enrolment of women in engineering, with a peak of 14.05% in 1996, the fact remains that women still represent less than 15% of the total engineering population. Urgent action clearly needs to be taken to encourage more women to enrol in engineering.

Such a situation in tertiary education has obvious consequences for the engineering profession itself. In the June 1998 issue of *Engineers Australia* of the Institution of Engineers, Australia, it was reported that women represent only 4% of professional engineers in Australia. If current trends in university enrolments for engineering courses continue, equal numbers of men and women in the profession will not be achieved for decades [1].

Similar trends have been reported in other countries. In India the difference between male and female enrolments in technical education is much greater. It was only in the early sixties that women started joining technical institutions, and while there has been a gradual increase in the rate of female participation, it has been extremely slow [2].

In the 1980s in the United States, more than 15% of engineering undergraduate students were women, compared to about 1% in 1970 [3]. However, the increase may now be levelling off; recent research indicates that there has been no improvement in the participation rate of females in engineering since the peak of 15% in 1987 [4]. These statistics for engineering do not compare favourably with the sciences and other professional disciplines. In terms of professional workforce, the percentage of women in engineering is markedly lower than in other science and technical fields. For example, some 20% of chemists, and 29% of computer specialists are women, but only 5.8% of engineers are women [3].

Considering that women constitute slightly above 50% of the general population, they are greatly under-represented in the engineering profession [3].

ANALYSIS OF STATISTICAL DATA

The entire picture showing the participation of women in engineering education can only be seen by examining the long-term trends in the enrolment of women in engineering courses. Figure 1 presents statistical data showing the overall changes in enrolment in engineering disciplines in the Faculty of Engineering at Monash University in the period 1969–1999. All the presented numerical results are based on the statistical data compiled by the Division of Budget and Statistics at Monash University.

Women in engineering

It can be seen that while enrolment in engineering courses at Monash University have more than doubled in the early 1990s, the huge gap between male and female participation has not

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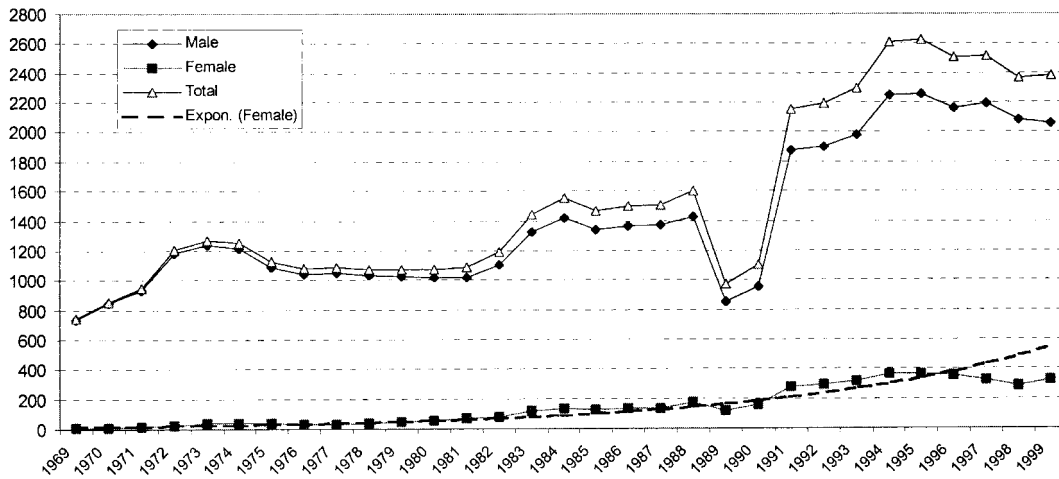


Fig. 1. A graph showing the overall changes in enrolment in engineering disciplines (1969–1999).

been reduced significantly because the level of participation of women in engineering education has not increased proportionally. Key observations concerning the enrolment of women in engineering courses are as follows:

- The rate of participation of women in engineering courses from 1969–79 was very low.
- The situation improved slightly from 1980–87, reaching 9.0% of the population.
- Further improvement can be seen between 1988–93.
- The enrolment of women reached its peak of 14.05% in 1996.
- A slight decrease in the number of female enrolment in engineering courses is recorded in 1998, with a small improvement in 1999.

It has to be pointed out that globally there has been a decrease in the overall enrolment in engineering courses since 1996. At Monash University, for example, overall enrolment decreased by 1.32% in 1997 and further 2.04% in 1998 from the 1996 figure.

Women in science

Some statistical data and observations concerning enrolment in science are presented in this paper for the purpose of comparison between the two closely related disciplines. Similarly to the engineering disciplines, much concern has been expressed about the falling interest of school leavers in science. Figure 2 shows the overall changes in enrolment in science disciplines at Monash University over the period of 1969–1999. Although the overall enrolment in science disciplines has fluctuated over the last ten or so years, the level of enrolment is fairly healthy. Observations concerning the participation of women in science disciplines are:

- In 1969 the enrolment of women in science disciplines was already 26.9%.
- On average there was a steady increase in the enrolment of women in science courses from 1970–92.
- The participation rate of women in 1993 is almost double that of 1969.

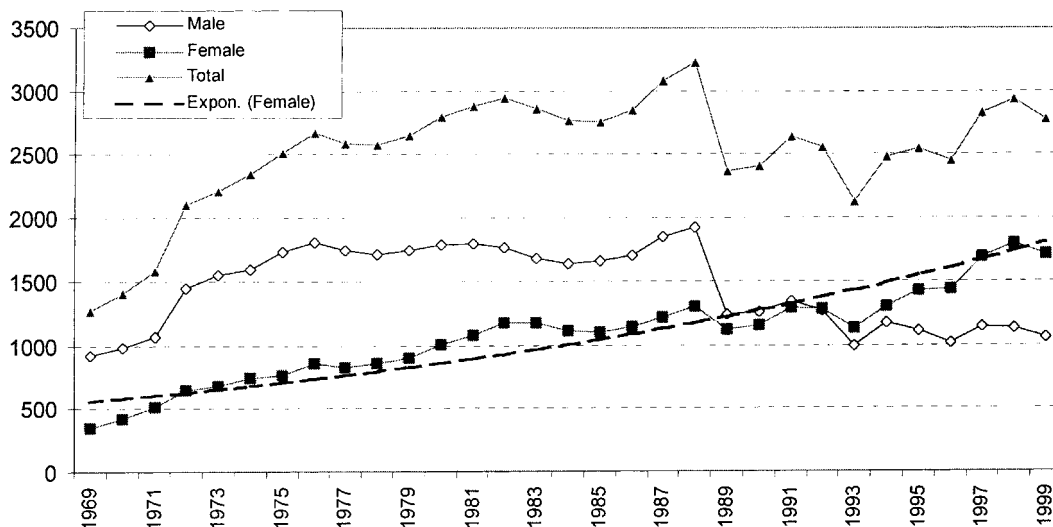


Fig. 2. A graph showing the overall changes in enrolment in science disciplines (1969–1999).

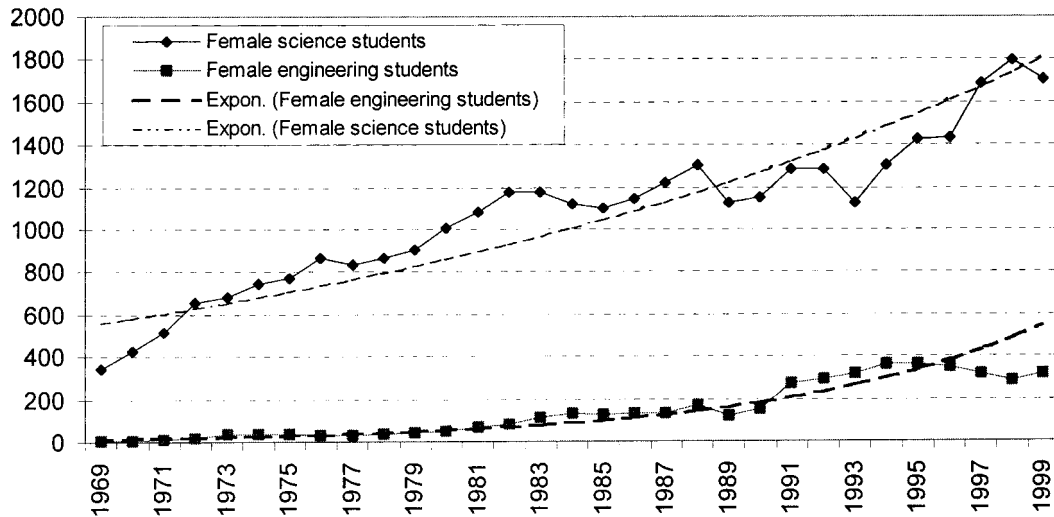


Fig. 3. A graph showing the comparison of women enrolments in science and engineering disciplines.

- From 1993 onwards the enrolment of females in science has outnumbered that of males.
- The number of women in science peaked in 1996 at 61.31%.
- The enrolment number of women dropped slightly in 1999. However the ratio of women to the total enrolment has improved by 0.40%.

It can be observed that the rate of enrolment of women in science is much greater than that of women in engineering and that the figures show a huge improvement in the participation of women in science disciplines. The comparison of women enrolments in science and engineering disciplines is shown in Fig. 3. The following observations can be made:

- More women enrol in science courses rather than engineering.
- The distribution between the gender groups in science education is more balanced than in engineering.
- Engineering is predominantly a male-dominated discipline.

FACTORS THAT MAY DETER WOMEN FROM STUDYING ENGINEERING

It is particularly important to determine the reasons why women do not choose engineering as a profession. The author is of the opinion that capability and aptitudes are not important issues because women engineers have demonstrated that they are just as capable as their male counterparts. However, as the statistics confirm, engineering is predominantly a male occupation, and women, who are in the minority, will always therefore have difficulties fitting into the male-dominated and oriented structure.

It has been observed that often women do not feel a sense of belonging, or have not developed the

confidence to work, in such a male-orientated environment. Many females find engineering schools to be stressful environments in which they experience a sense of isolation and a lack of acceptance on the part of the faculty staff and the male students [3].

The design of engineering curricula has also been seen as a critical factor that may discourage and disadvantage female students, as curricula have been devised and developed to suit the needs of male students, grossly neglecting the needs of female students. For instance, in India, girls undertaking engineering disciplines admitted that they were slightly handicapped due to less physical strength when working in some of the laboratories and workshops [2].

Another reason could be of a psychological nature. For example, women are taught to think that they do not possess the essential qualities and skills to become engineers. A common perception is that because engineering is a technical area, it is, as such, more suited to males. Minton and Schneider have, for example, pointed out differences in the qualities of the sexes. According to them, females tend to be superior to males in verbal fluency, reading comprehension, finger dexterity, and clerical skills, and that males tend to surpass females in mathematical reasoning, visual-spatial ability, and speed and co-ordination of large bodily movements [5]. In part these findings are a function of differences in the ways in which boys and girls are treated in our society. Girls are usually expected to be more accomplished in linguistic and social skills, and boys are supposed to be better at mathematical, mechanical and other problem-solving tasks [6]. In more general terms, women are thought to be non-technical and men more technically focused. Since engineering is considered to be a technical study area, embracing mathematical, mechanical and problem-solving tasks, the Monash University statistics, indicating that 85% of enrolments

in engineering at Monash University are male, should come as no surprise.

Studies conducted at the University of Sydney by Ballard and Pudlowski on a group of secondary school students present some interesting observations about the performance of male and female students on simple electrical engineering tasks [7]. Students were required to perform a number of exercises during a day-long workshop that was designed to introduce high-school students to electrical and electronic engineering. In the first exercise, students were asked to build a simple crystal radio set by following instructions given in their workbook, and then to assemble the radio on a plug-in electronic breadboard, with the electronic components being supplied. After testing and demonstrating its operation, they followed instructions on how to enhance its performance through use of an operational amplifier, a speaker and a power supply.

It was found that the majority of students performed this task very well, although it was noticed that the majority of females were inexperienced in the kind of construction and manual operation techniques necessary for this type of work.

The second exercise required students to investigate the operation of the basic logic elements that form the building blocks for digital circuits. Electronic components were subsequently supplied to design a simple car alarm.

Again, it was found that girls required support to overcome their inhibitions in utilising unfamiliar equipment and components, but then adapted well to solving these quite abstract problems.

The third exercise was to experiment with a digital logic trainer, which required the possession of more abstract problem-solving skills to be successful. The girls were rated very highly in this experiment in which they demonstrated high levels of understanding and accomplishment in contrast to the boys, who found this exercise far more difficult.

The last exercise was *An Electrical Engineering Aptitude Test* (EEAT). The test places particular emphasis on electrical circuit theory through pattern recognition. It endeavours to measure the visual ability to recognise circuit components and fundamental circuit topology and structures taught in high-school physics. In evaluating the EEAT, the boys indicated that they found it to be extremely difficult. The girls too assessed the EEAT to be difficult, but found it more beneficial than the boys and were satisfied with their accomplishment. The girls achieved slightly better results than their male counterparts, suggesting that the girls had better problem-solving skills and that they were more logical in following instructions and putting things in sequential order than the boys. Moreover, the results indicate that the girls have higher visual-spatial ability than the boys, which contradicts Minton and Schneider's findings.

What is demonstrated by this research is that although the females initially experienced difficulties, in particular in those exercises that required motor and manipulation skills and fundamental assembly techniques, they could perform equally well as their male counterparts. When the girls became more familiar with the knowledge, technology and techniques used, they even rated higher where intellectual and abstract skills were required. This indicates that females were at least as capable of doing electrical engineering as males [7]. It can be generalised that female engineering students could bring a range of new skills, attributes and attitudes to engineering education.

Another critical issue for engineering education is its general failure to address human issues, which may explain why most women in engineering congregate around those disciplines viewed as *soft engineering*. As a discipline, engineering has been almost entirely isolated from the humanities and has, as such, been taught outside of a social context. A greater number of women would probably be attracted to engineering if changes were made to curricula to include topics, concepts and ideas from the humanities, which would make engineering more relevant to society as a whole.

While more and more universities today are recognising the need for a balance between technical and non-technical content in engineering, it is believed that it will take a long time before such changes can be implemented effectively into engineering curricula.

Several important factors, which may influence women to study engineering have been identified by Rosati and his associates in their surveys conducted in 1988 and 1993 [8, 9]. The identified factors were helpful in the formulation of the issues and views, concerning the attitudes of female students when choosing engineering studies. Also, they provided some background for the formulation of the conclusions drawn in this paper.

WOMEN IN SCIENCE VERSUS WOMEN IN ENGINEERING

One reason why women prefer science to engineering could be due to their lack of exposure to engineering or engineering-type subjects in secondary education. Physics and mathematics are the closest subjects to engineering, and these two subjects typically attract males, with females typically enrolling in chemistry or biology. The early exposure of female students to these science disciplines is then reflected in their pursuit of science at the tertiary level. As has been observed:

... for women, early exposure to physics in particular appears to be a key factor in the later choice of engineering as a course of study. Poor preparation in science and mathematics limits the appeal of engineering to these groups and increases the attrition among those who do study engineering, especially

among minority students. Educators should develop strategies to increase the size of the initial science/mathematics pool of minorities and to reduce attrition all along the educational pipeline. Such strategies should include innovative ways to increase the appeal of mathematics and physics for female students [3].

It has been found that the structure of engineering curricula contains more hard components, which could be a major factor in discouraging women from entering the field. Science, on the other hand, is structured differently and has a greater balance between the hard and soft components, including both non-technical and technical subjects. This could be a reason for its attraction to women. Lack of space does not allow the author to address this issue in any greater detail.

POSITIVE OUTLOOK

The decline in the rate of growth of women enrolling in engineering paints a fairly gloomy picture and has raised concerns among many engineering educators; nonetheless the scene is not all bad and some positive initiatives have been undertaken to promote the participation of women in engineering.

Significant changes took place in the Faculty of Engineering at Monash University in 1998, with the introduction of a new curriculum with a common first year for all Departments in the Faculty.

For example, there is a great expectation that the newly introduced first year subject *Engineering Context*, which has a major focus on, and treatment of, the issues of engineering interaction with the community, will have a positive impact on women's perception of, and participation in, engineering [10]. However, the effect of the introduction of the new curriculum is yet to be determined.

An important women-centred initiative undertaken by the UNESCO International Centre for Engineering Education (UICEE) in 1996 was the introduction of a *Women in Engineering Education Scholarship Scheme*. Scholarships under the scheme have provided significant support, opportunity and encouragement for women to pursue research in engineering, and in engineering education in particular. The objective of such scholarships is to increase the number of women as academic teachers in engineering who would be role models for female secondary school students,

as well as for engineering students who have already chosen engineering as their profession.

Other activities that help to promote women in engineering include:

- the establishment of centres for women;
- the running of women in engineering forums and conferences;
- the setting up of women in engineering project officers across universities in order to deal with the underlying issues. If universities are aiming at increasing the participation of women in engineering, the continuation of such activities is vital for the future of engineering.

CONCLUSION

It has been found that increasing the enrolment of women in engineering depends very much on the manner in which the message about engineering is conveyed to students at the secondary level of education.

Teachers need to be more responsive. They need to be more sympathetic, supportive and encouraging of female students studying engineering. There need to be more introduction to engineering units or subjects at the secondary level to raise female students' awareness of engineering.

At the tertiary level, more effort needs to be taken in designing engineering curricula to include the humanities and non-technical content and to remove those aspects of curricula that deter women from undertaking engineering courses.

Engineering departments should devise more aggressive strategies to attract female students to engineering courses, for instance by organising special seminars for secondary school students.

Such seminars can provide students with the opportunity of learning about a particular branch of engineering, making themselves familiar with the technologies and processes used, as well as research achievements. Academics must go out to young students with a message about what engineering involves and why women should become engineers, particularly as women can bring a different dimension, qualities and skills to engineering.

Generally, more studies need to be devised and carried out on the existing population of female engineering students to learn about their personal experiences. This could assist in finding more effective ways to attract a greater number of women to engineering in the future.

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