Enrolment of women in engineering and technology degree programmes in Australia

D.Q. Nguyen & Z.J. Pudlowski

World Institute for Engineering and Technology Education and Monash University
Melbourne, Australia

ABSTRACT: Increasing the number of women in engineering and technology education has been a real challenge for many engineering and technology schools in Australia. The national trend and participation of women in engineering courses by field of education across universities in Australia in the period 2005-2009 is presented and discussed in this paper. The statistical data gathered here indicate that the female rate of participation in engineering and technology courses, comprising all academic levels, currently stands at more or less 15 percent. Although universities have managed to retain this current rate, it is still regarded as unsatisfactory considering that women make up approximately 50 percent of the general population. The statistical data provide evidence that more work is required, beginning at primary and secondary school levels, to increase the number of women seeking to enter engineering and technology courses at the tertiary level.

INTRODUCTION

The enrolment of women in engineering and technology courses across Australian universities remains consistent but at the same time there has been no indication that the female participation rate in engineering and technology will exceed the peak of 15.7% achieved in 2008. While it is pleasing to observe that over the last three decades more women have chosen engineering and technology as an option for tertiary education, the fact remains that women still represent only 15% of the total enrolment in engineering and technology.

Considering that women constitute slightly above 50% of the general population, they are greatly under-represented in the engineering and technology profession [1]. Clearly, more work is required on the part of the universities to encourage more women to enrol in engineering and technology.

Although the Australian national statistical data have revealed that chemical engineering (e.g. process and resources engineering) is a relatively popular choice among women, the opposite finding, surprisingly, was reported in most countries of the European Union (NSP-EU, 2001) [2]. In Australia, of the classical engineering and technology fields, programmes in automotive engineering and technology, maritime engineering and technology, and mechanical and industrial engineering and technology appear to be the least appealing to female students, attracting about 10% of the female population, compared with the average of about 15% female presence overall.

Similar findings were also reported in most countries of the EU. It was reported that women represent about 25% of the total number of enrolments in engineering courses (NSP-EU, 2001) [2]. This number is still very small in comparison with the number of women enrolling in science courses, especially in the humanities and the social sciences. It is clear that more work is needed to increase the participation of women in engineering and technology.

The statistics for engineering and technology do not compare favourably with the sciences and other related disciplines. Although the overall enrolment in science disciplines has fluctuated, the level of enrolments is still satisfactory. Earlier studies conducted by Nguyen have shown that female students are more likely to enrol in science courses at universities [3].

One reason why women prefer science to engineering and technology 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 technology, and these two subjects typically attract male students, with women 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.

It has been observed that

> *…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* [1].

It has been found that the engineering curricula contain 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.

STATISTICAL DATA ANALYSIS

The overall picture showing the participation of women in engineering and technology education can only be understood by examining the long-term changes in the enrolment of women in engineering and technology courses. Figure 1 presents statistical data showing the overall trend in national enrolment in engineering and technology in Australia in the period 2005-2009.

WOMEN IN ENGINEERING EDUCATION

It can be seen from Figure 1 that while enrolments in engineering and technology courses at Australian universities have increased slightly each year from 2005 to 2009, the huge gap between male and female participation has not been reduced significantly because the level of participation of women in engineering and technology education has not increased proportionally. Briefly, the key observations concerning the enrolment in engineering and technology courses between the genders are as follows:

- Exponential growth can be observed in the overall enrolment in engineering and technology courses in 2005-2009.
- The rate of participation of women in engineering and technology courses from 2005-2009 has improved slightly but is still very low when compared to the male enrolments.
- From 2005 onwards, the enrolment of men in engineering and technology has outnumbered that of women.
- The enrolment of women reached its peak of 15.7% in 2008.
- There is a huge disparity in the distribution between the gender groups in engineering and technology education.
- Engineering and technology is predominantly a male-dominated discipline.

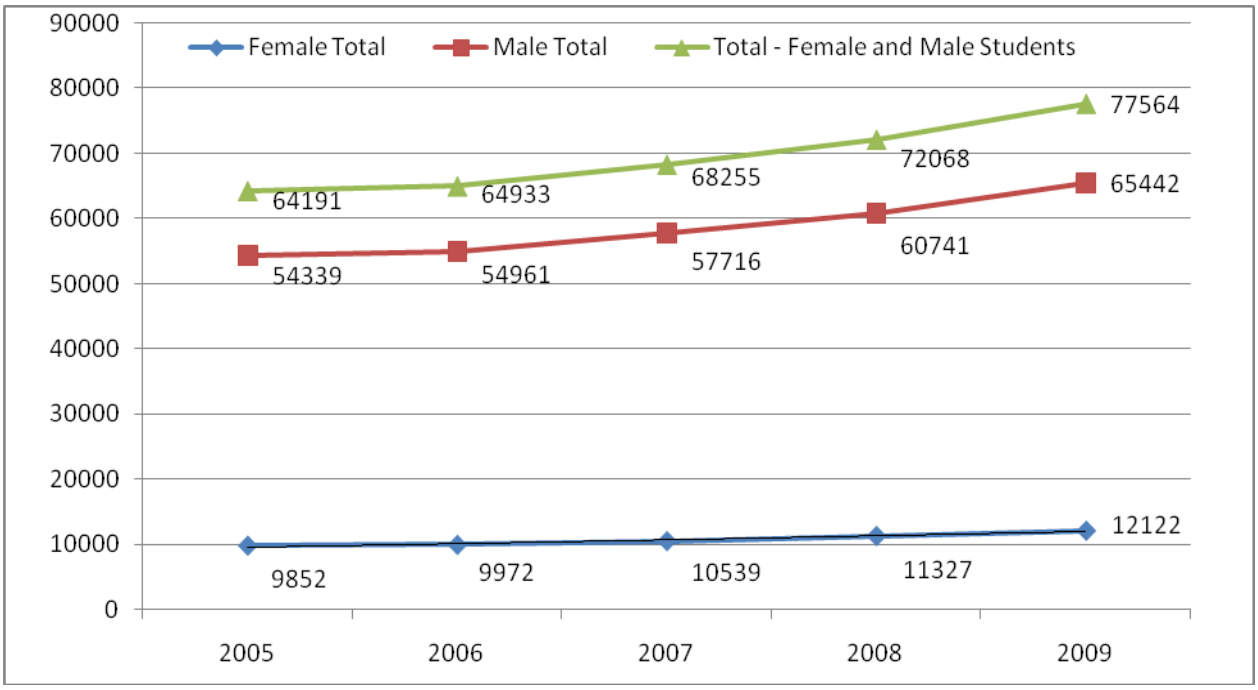

Figure 1: A line graph showing the overall changes in the national enrolment in engineering and technology disciplines in Australia (2005-2009).

In addition to the number of enrolments of women in engineering and technology courses, an even more interesting issue was the engineering and technology specialisations that attracted the highest female enrolment and this was also looked at and examined in detail. Figure 2 shows the enrolments of women in engineering and technology courses in Australia by the field of education over the period of 2005-2009. The key observations concerning the enrolment in engineering courses by the field of education are as follows:

- Engineering and related technologies appears to be a favourite amongst the women attracting the highest number of female enrolments. This narrow field of education includes sub-engineering disciplines such as environmental engineering, biomedical engineering, fire technology, etc.
- The second most popular choice amongst women is process and resources engineering also showing a steady increase in enrolment number over the period of 2005-2009.
- Ranking in third place is electrical and electronic engineering. However, the enrolment of women in this narrow field has shown a decline over the period of 2005-2009.

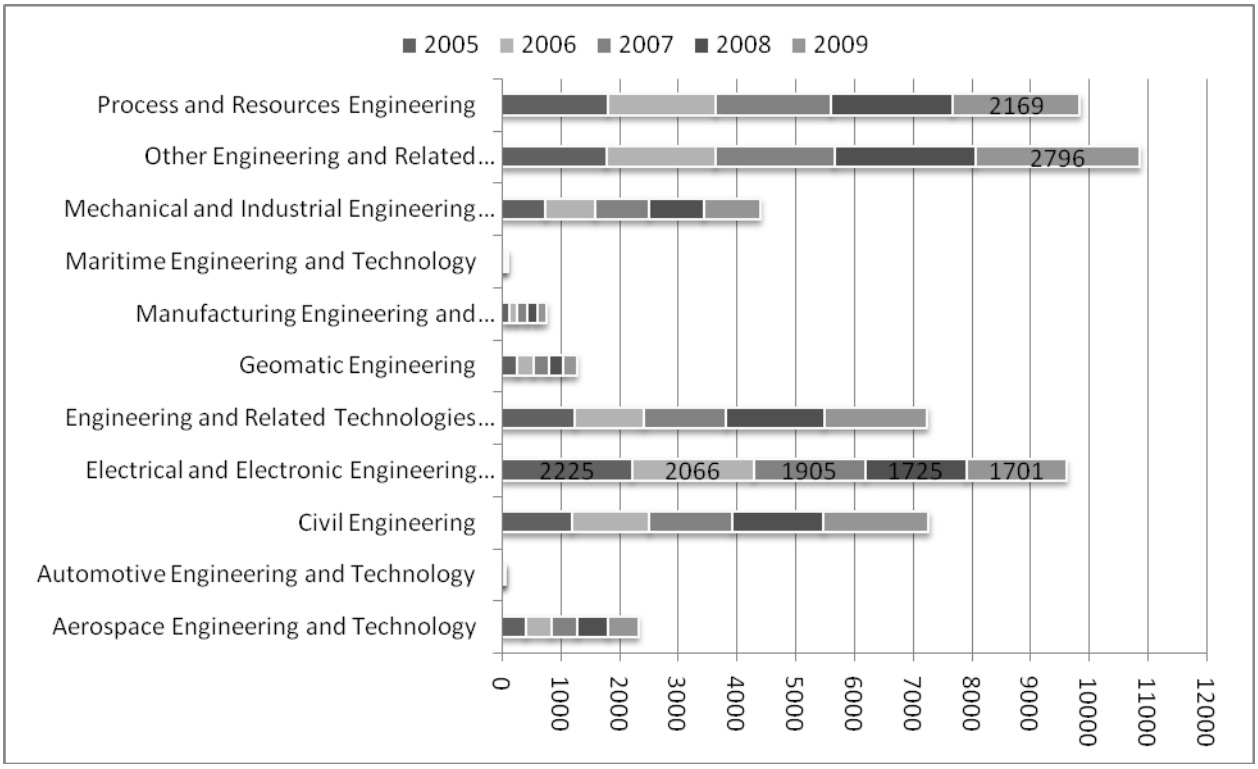

Figure 2: The enrolment of women in engineering and technology courses in Australia by a specific field of education (2005-2009).

POSSIBLE FACTORS DETERING WOMEN FROM STUDYING ENGINEERING

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

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 women find engineering and technology 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 [1].

The design of engineering and technology curricula has also been viewed as a critical factor that may discourage and disadvantage female students, as curricula have been devised and developed to suit, primarily, the needs of male students, grossly neglecting the needs of female students. For instance, in India, girls undertaking engineering and technology disciplines admitted that they were slightly handicapped due to their lower physical strength, when working in some of the laboratories and workshops [4].

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 and technologists. A common perception is that because engineering and technology is a technical area, it is, as such, more suited to men. For example, Minton and Schneider have pointed

out differences in the qualities of the sexes. According to them, women tend to be superior to men in verbal fluency, reading comprehension, finger dexterity and clerical skills, and that men tend to surpass women 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 and technology are considered to be technical study areas, embracing mathematical, mechanical and problem-solving tasks, the statistics, indicating that 85% of enrolments in engineering and technology are male should come as no surprise.

Studies conducted earlier 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 daylong 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 girls 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 did.

Moreover, the results indicated that the girls had a higher visual-spatial ability than the boys did, which contradicts Minton and Schneider's findings.

What is demonstrated by this research is that although the girls initially experienced problems, in particular in those exercises that required motor and manipulation skills and fundamental assembly techniques, their overall performance was equal to 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 girls were at least as capable of doing electrical and electronic engineering as boys [7]. It can be generalised that female engineering and technology students could bring a range of new skills, attributes and attitudes to engineering and technology education.

Another critical issue for engineering and technology education is its general failure to address human issues, which may explain why most women in engineering and technology congregate around those disciplines viewed as *soft engineering*. As a discipline, engineering and technology has been almost entirely isolated from the humanities and as such, has been taught outside the social context. A greater number of women would probably be attracted to engineering and technology if changes were made to curricula to include topics, concepts and ideas from the humanities, which would make engineering and technology 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 and technology, it is believed that it will take a long time before such changes can be implemented effectively into engineering and technology curricula.

Several important factors, which may influence women to study engineering and technology 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 and

technology studies. In addition, they provided some background for the formulation of the conclusions drawn in this paper.

POSITIVE OUTLOOK

The slow growth rate of women enrolling in engineering and technology has raised concerns among many engineering and technology educators. Nonetheless, the scene is not all bad and some positive initiatives have been undertaken to promote the participation of women in engineering and technology.

For example, in 1996, an important women-centred initiative undertaken by the then UNESCO International Centre for Engineering Education (UICEE), which was based at Monash University, Melbourne, Australia, 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 technology, and in engineering education in particular. Several higher degrees have been achieved as a result of this scheme.

The paramount objective of such scholarships was to increase the number of women as academic teachers in engineering and technology, who would be role models for female secondary school students, as well as for engineering and technology students who have already chosen engineering and technology as their profession.

Previous studies have shown that environmental engineering courses have proved to be successful in attracting female students. Following on from this success, perhaps one solution would be to integrate environmental units into general engineering and technology curricula to make them more appealing to women.

Other activities that help to promote women in engineering and technology include the establishment of centres for women, the running of women in engineering forums and conferences and the setting up of women in engineering and technology project officers across universities in order to deal with the underlying issues. If universities are aiming at increasing the participation of women in engineering and technology courses, the establishment or continuation of such activities is vital for the future of engineering and technology.

CONCLUSIONS

It has been found that increasing the enrolment of women in engineering and technology depends very much on the manner in which the message about engineering and technology 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 and technology. There needs to be a longer introduction to engineering and technology units or subjects at the secondary level to raise female students' awareness of engineering and technology.

At the tertiary level, more effort needs to be taken in designing engineering and technology curricula to include the humanities and non-technical content and to remove those aspects of curricula that deter women from undertaking engineering and technology courses. Furthermore, engineering and technology departments should devise more aggressive strategies to attract female students to engineering and technology courses, for instance, by organising special seminars for secondary school students.

Such seminars can provide students with the opportunity to learn about a particular branch of engineering and technology, 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 and technology involve and why women should become engineers and technologists, particularly as women can bring different dimensions, qualities and skills to engineering and technology.

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.

As the statistics confirm, and taking into account the historical perspective, engineering and technology is predominantly a male occupation. Hence, it is not surprising to find that 85% of the students enrolled in engineering and technology courses in Australia are men. Women, in the minority in these courses, always will have difficulties fitting into the male-dominated and oriented environment. Therefore, prompt action is required in order to remedy this critical situation.

REFERENCES

1. Engineering Education and Practice in the United States, Foundations of Our Techno-Economic Future. Committee on the Education and Utilisation of the Engineer, Commission on Engineering and Technical Systems and National Research Council, Washington, D.C., USA (1985).

2. National Statistical Profiles for EU Member States and Associated Countries (NSP-EU) (2001), http:ec.europa.eu/research/science-society/women/wssi/pdf/annex3.pdf.
3. Nguyen, D.Q., The status of women in engineering education. *Inter. J. of Engng. Educ*., 16, **4**, 286-291 (2000).
4. Hira, D.S., Women's participation in technical education in India. *Proc. 1st Asia-Pacific Forum on Engng. and Technol. Educ.,* Melbourne, Australia, 275-278 (1998).
5. Minton, H.L. and Schneider, F.W., *Differential Psychology.* Monterey, CA: Brooks/Cole (1980).
6. Lewis, R.A., *Psychological Testing and Assessment.* (7th Edn), Boston: Allyn and Bacon (1991).
7. Ballard, S.J. and Pudlowski, Z.J., Electrical engineering career orientation system. *Research and Development in Higher Educ.,* Sydney: HERDSA, **11**, 194-197 (1989).
8. Rosati, P.A. and Surrey, S., Female perspectives of engineering education: a qualitative study. *Inter. J. of Engng. Educ*., 10, **2**, 164-170 (1994).
9. Rosati, P.A. and Becker, M., Student perspectives on engineering. *Inter. J. of Engng. Educ*., 12, **4**, 250-256 (1996).