

Increased female participation into engineering education through specialised courses

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***Abstract:** Research has shown that female participation into engineering courses has a very poor record especially in mainstream courses such as Mechanical, Electrical and Civil engineering. This paper refers to local and international reports on this issue and the success of the Product Design Engineering course to attract a higher percentage of female students. The study will reveal female enrolment into the course, performance during the course and employment after graduation over a ten year period that this course has been offered at Swinburne University of Technology, Melbourne, Australia. The paper will support the position that higher female participation in the engineering profession is a necessity and that educational institutions have the ability as well as the responsibility to offer specialised courses that are conducive to higher female participation.*

Introduction

The Australian Learning and Teaching Council (ALTC), in its “Pathways and Access to Engineering Education” (Godfrey & King, 2011) study has revealed that ‘under-representation of women in engineering degrees in Australia has continued despite twenty years of initiatives’. The same study reports that programs at Australian Universities to attract female students in 1990’s, are almost all disbanded. As a result the trend that saw female participation into engineering courses reach almost 20% has been reversed and has since 2000 been fluctuating around 14%. When referring to women not taking up an engineering degree, the report highlights four main reasons; (a) not having the prerequisite studies at High School, (b) those that have the prerequisite studies opt for studies in medicine, veterinary science or architecture, (c) the fact that female students prefer courses that lead to professions perceived as ‘used for the good of society’ and (d) because engineering courses do not offer an inclusive curriculum and learning environment.

A number of recommendations are made in the report for increasing recruitment and retention of women in engineering courses. The most common of which is to have a Women in Engineering (WiE) program within Engineering Faculties. Although such initiatives have shown to be effective in increasing participation by women into engineering programs, personal experience of more than twenty years in engineering education, has lead to the conclusion that these have to be consistently maintained or else the trend is reversed. This is also indicated in same report, “Pathways and Access to Engineering Education”, where it is reported that although “it is difficult to find compelling evidence that the disestablishment of Women in Engineering programs has resulted in lower participation by women. Trends within institutions do, however, appear to confirm that within two or three years of a program being disbanded, female participation drops by 4 – 5%”.

Influence of professional specialisations

Anecdotal evidence indicates that different genders show preference to specific professions. Revealing examples are primary school teaching and nursing, both of which are highly preferred by female professionals. This is obviously not the rule across all professions and this statement is not supported by statistical data in this paper, but it highlights that there may be preferences on professional careers that are influenced by gender differences.

Statistics from studies about women participation in engineering, presented at the “Women in Engineering Forum” during the Annual Conference of the Australasian Association for Engineering Education, 2006, show that female participation varies according to engineering specialisations. Fig.1, shows that some courses attract more female students than others.

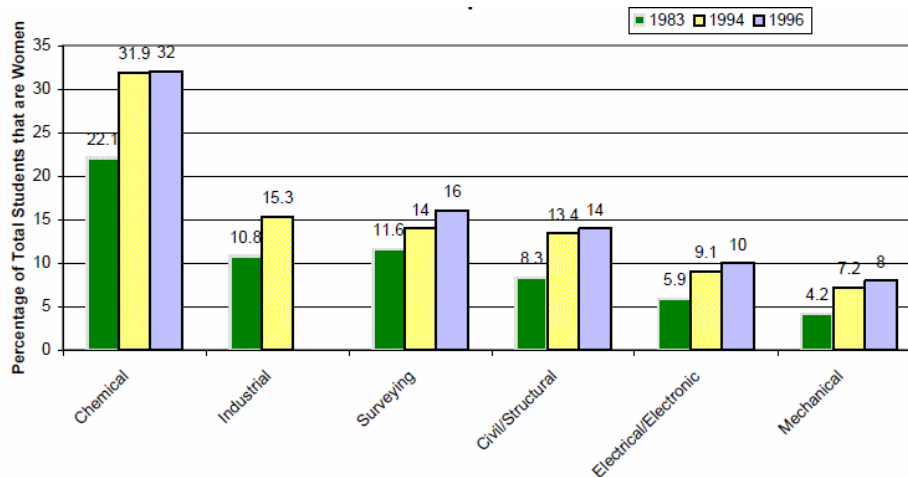


Figure 1: Australian Undergraduate Women Students by Discipline

Other research done on the topic of gender disparities in engineering (de Cohen and Deterding, 2009), shows that female students in engineering courses show preference toward some specialisations as shown in Figure 1. For example Chemical Engineering attracts higher female participation than the traditional “main stream” engineering courses of Mechanical, Civil and Electrical engineering. Although as an engineer I do not agree that traditional engineering courses are not used for the good of society, it is a possibility that they are not perceived to be as such by the female students during their pre university studies. This may be reinforced by the results reported in the same study that shows enrolment in Mechanical and Electrical & Electronics courses to be 13% and 12% female enrolment respectively in contrast to 38% and 37% female enrolment for Bioengineering and Environmental engineering respectively. Preference by female applicants for courses that are “for the good of society” is confirmed by yet another study in Australia (Hillman & Rothman, 2003). The results from this study, shown in Fig. 2, indicate that engineering has the lowest female participation whilst Health and Arts & Humanity have the highest.

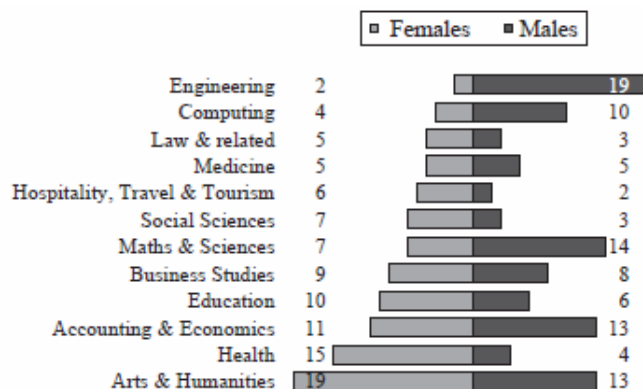


Figure 2: Field of study by gender, mid 1990s

These statistics beckon the suggestion that one way to increase female participation in engineering, is by offering university courses in engineering specialisations that female candidates can see clearly their contribution to society. Courses such as this already exist in many universities, Biomedical, Chemical, Environmental etc. Therefore, the suggestion in this paper is to give more emphasis in providing more courses which are subsets of the “mainstream” engineering courses. By nature, engineering and technology has applications in the majority of professions in existence today. Therefore, there are great opportunities to provide engineering courses that extend on traditional engineering disciplines in ways that females perceive to be “used to the good of society”.

Product Design Engineering (PDE) course

Swinburne University has for some fifteen years now, been running the Product Design Engineering course. This is a course that combines studies from the disciplines of Industrial Design and Mechanical/Manufacturing engineering. A combination of studies that at first glance seem very diverse, with industrial design being so open ended, creative, innovative, “right brain” oriented and engineering that follows a very disciplined and methodical approach to addressing problems, “left brain” analytical thinking. And yet, with little effort, it was realised that unless a piece of creative work will be hung on a wall, it has to be made at some stage, which of course will need engineering. So, “why not” involve an engineer as early as possible in the design process? A combination of knowledge and skills from both of these areas potentially avoids conflict of interest, achieves functionality in a product that is aesthetically pleasing and faster concept to market timeline. Many other areas could complement engineering to provide courses that are ‘used the good of society’ while achieving good outcomes for its students.

Curriculum design

Hybrid courses such as the Product Design Engineering, (de Vere, Melles & Kapoor, March 2010) may be easy to conceive but hard to implement. There are many logistical issues which need to be addressed that even “well lubricated” academic and administrative machines in University Faculties, find it difficult to implement. This is especially so when collaboration between two diverse Faculties is required. However, a well designed curriculum, with clear allocation of responsibilities and duties can, just as the PDE course has for fifteen years, run without much if any difficulties. The course objectives have to be well defined, in the case of the PDE course these were based on Engineers Australia Accreditation requirements and its curriculum agreed by the two disciplines. All administrative functions are with one of the faculties, in this case with the Faculty of Engineering, although it is a purely collaborative effort by both faculties to achieve outcomes appreciated by students and industry.

However, at the core of a successful “hybrid” course is the design of the curriculum. The main feature of which is the integration of diverse studies from the first week of the course to the last. Unlike Double Degrees, this study integration achieves a comprehensive learning environment for the students where they are guided through implementation of knowledge gained from both areas of study. In the case of the PDE course, Engineering knowledge gained in lectures, tutorials and laboratories, is implemented though the design of a product. For example, knowledge gained from “Thermodynamics and Heat Transfer”, it is used in designing a product that requires that knowledge e.g. a portable Air Conditioning unit. The project brief requires that all engineering calculations for thermal efficiency and functionality are completed while achieving a product that is visually competitive in a retail store, Figure 3.

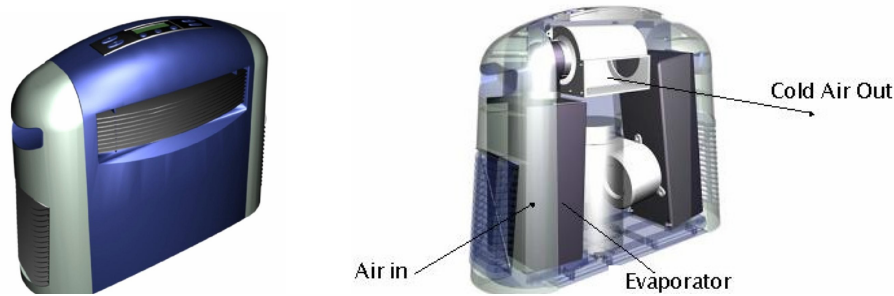


Figure 3: Student project on A/C unit

Student performance

All engineering units within the PDE course are common with the other engineering courses. Although there were concerns that due to the “design” nature of the course, it will attract students that are not inclined toward science and engineering, thus far, this has not been the case at all. The average entrance ranking (ENTER score) for the PDE course, was marginally over 80%. A fair number of the Vice Chancellor’s scholarship recipients come from applicants for the PDE course, which requires an ENTER score over 95%. A survey, done yearly by the Education Development Coordinator of the Engineering Faculty, has consistently shown that PDE students perform as well if not better than students from other engineering courses. Notably, the top engineering graduate of the Faculty of Engineering and Industrial Sciences at Swinburne University for 2010 was a female student from the Product Design Engineering course.

What the female students and graduates from the PDE course say

In a survey done in 2011, female students and graduates (13 and 15 responses respectively) were very enthusiastic about the course and those employed in the engineering industry had progressed successfully toward management positions. When asked whether they would have chosen to study engineering if PDE wasn’t available. The results revealed that 68% were not going to take up engineering if the course did not offer a specialisation that was attractive to them. Some of the comments on why they would not take up an engineering course included words such as “dry” and “not creative enough”. However one interesting response was *“It was the design part that drew me to the course. Only later in the studies I found that the engineering part of the course was actually just as much my cup of tea as the design was”*

Most female students believe engineering knowledge will give them a better standing as Product Designers whilst some appreciate the wide spectrum of skills and knowledge they will gain from the course in relation to future employment. This is confirmed by the responses received from female graduates that now work in a great variety of specialisations, which range from engineering bias in manufacturing and quality assurance, to research in a government department. Some continued to postgraduate studies to become a patent attorney and a High School teaching of Design and Technology. Most notable is the fact that many have progressed to managerial positions in client related areas and project management. One example of a response with reference to working position was *“I am now working as a project engineer for the mechanical department in my company. We are developing the equipment that goes onto the oil rigs around the world. I'm managing projects from start to finish. I will say I use my engineering knowledge every day, working with assemblies, drawings and important engineering specifications”*.

What the lecturers say

Lecturers from the Product Design Engineering course were interviewed to gauge the commitment and capabilities of female students. These lecturers came from the Faculty of Design at Swinburne University of Technology and some from the Faculty of Engineering. The quotes below show typical responses during these interviews.

Design

While PDE has a high percentage of female students in comparison to other Engineering disciplines, within the PDE course it has been observed in the design studio unit “PDE 1 and PDE 2”, that cohorts with a particularly high percentage of females or mature age students are more engaged. Such cohorts have displayed a peer dynamic that elevates motivation, engagement in class activities, initiative and the production of higher quality project work.

Female students in these PDE design studios generally tackle the engineering aspects of the design projects extremely well. A good example of this is outcomes of a plastics design project, that required a product to be designed and detailed for injection moulded production. Students were required to perform calculations for material thickness and assembly connections to inform the design process. The top two projects were created by female students, where the design outcome was shaped by the engineering exploration of material and manufacturing capabilities. One explored minimum material thicknesses for maximum strength, and the other looked at clever detailing for a complex structure to be injection moulded using only a two part die.

Engineering

One of the subjects where the difference between PDE and other courses becomes most evident is the subject “Machine Design”. This subject has a strong focus on the application of established theory to common machine elements and mathematical derivation. The purpose of this focus is explained to the students as being an essential skill to evaluate proposed innovations for viability. To help improve the exposure of all students to different aspects of engineering work groups are made up of a diversity of students based on cultural background and discipline (mechanical, product design engineering and robotics & mechatronics). In this subject the PDE students typically display a broader range of ability to apply mathematics to design (based on student feedback, the attitude displayed and marks), than do students from the other disciplines. However, the difference between genders is not so clear. This could be because of the still relatively small number of females in engineering in general. However, it is clear that the diversity between disciplines is greater than the diversity between genders when considering this aspect of engineering design.

What the statistics say

The Product Design Engineering course has been attracting a higher percentage of female students than the national average. Comparing data sourced from Swinburne University of Technology records with data published in Mills, J. E. (2010), the PDE course has clearly attracted consistently higher numbers of female participants. On average the national data reveals 15% participation whilst data from Swinburne University for the PDE course during the same period shows an average of 23% female participation. Fig. 4 shows the yearly comparison between the national average in Australia and the PDE course at Swinburne University of Technology.

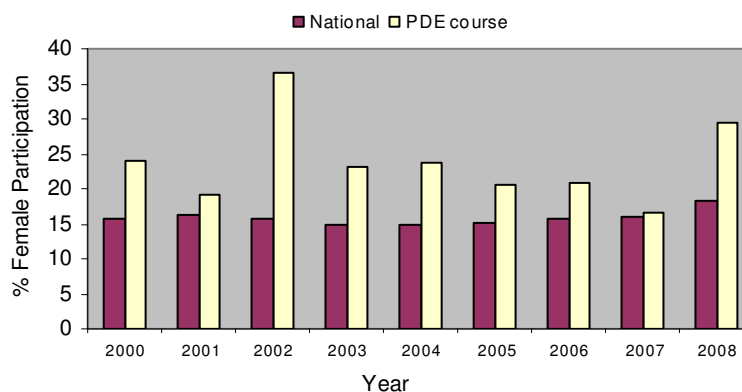


Figure 4: Female participation in engineering courses

These statistics refer to all engineering courses combined. As shown in Fig. 1, individual course statistics vary considerably between different courses. The Mechanical Engineering course is shown to have the poorest record in attracting female students. Having in mind that the PDE course is a combination of Mechanical Engineering with Industrial Design, the average of 23% female participation in the course becomes even more significant than originally thought. As stated by de Vere, Melles and Kapoor, (June 2010), ‘the PDE course has significantly more female students, averaging 25% for the last six graduating years, compared to 2% for mechanical engineering (from which half its subjects are derived)’.

The success of the PDE course to bring more women into engineering can also be measured by the graduation rates shown in Fig. 5. The data recorded over eight years show that graduation of female students from the course is steady if not better than enrolment. Although this is not synchronised data of the same cohort of students, it shows clearly the success of female students to complete the course.

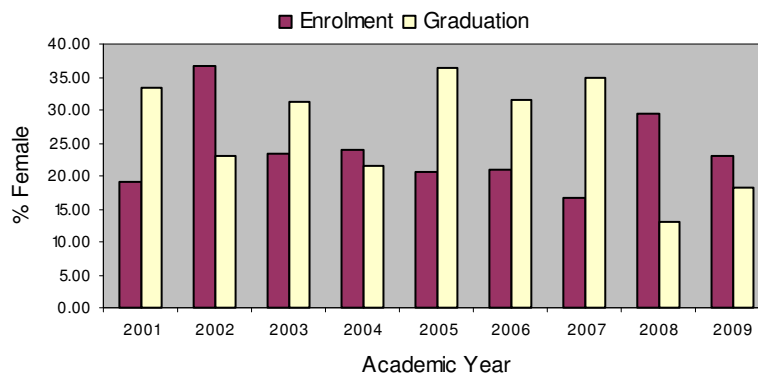


Figure 5: Enrolment and graduation statistics in PDE course

Conclusion

This paper looks at the topic of low female participation in engineering. Specifically regarding the barrier that some engineering disciplines are not perceived as being “used for the good of society”, as reported in current literature. The paper suggests that at institutional level, education can be used to address this issue by offering hybrid engineering courses that are combined with disciplines which are perceived as being more directly “used for the good of society”. Such courses should, of course, combine appropriate and complementary disciplines to extend the capabilities of traditional engineering disciplines. The Product Design Engineering (PDE) course at Swinburne University of Technology is a successful example of this approach.

Statistical analysis of data collected by surveying female students and graduates from the PDE course has shown that there is much to support that this course has consistently achieved higher female participation than the national average over a number of years. It also provides evidence that females excel in this discipline judged by retention and graduation rates and interviews with teaching staff.

Further studies to look at other combinations of engineering with complementary disciplines and research to gain better understanding of the perceptions and motivators that influence female participation into engineering courses will certainly assist in the effort of increasing female participation into engineering courses and the profession in general.

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