

# PERCEPTIONS OF 'ENGINEERING' – TOO LITTLE TOO LATE

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**ABSTRACT:** If we are to encourage a more diverse range of students to consider engineering as a career option, engineering must be part of the everyday language and awareness of all students, their teachers and parents. They must be familiar with the concept of an engineer in the 21st Century before important subject choices are made. This paper outlines research into the level of understanding of 'engineering' by school students. The findings of a literature review and research in NSW schools underpins the hypothesis that unless students with ability are familiar with engineering before high school they may stream themselves out of engineering as a career choice. Our recommendation is that promotion of engineering and engineering career paths should target primary school, junior secondary school students, their teachers and parents, and that the marketing approach must focus on the interests and understandings of these students. The invisibility and misrepresentations of engineering are important issues that must be addressed if this marketing is to be effective in encouraging diversity in the engineering profession. The question that then faces the engineering profession is 'Whose job is it?'

**KEYWORDS:** student diversity, intake attributes, perceptions of engineering, articulation of engineering

## INTRODUCTION

University engineering faculties need to find out why students choose engineering and a particular university for their first undergraduate degree to support decision-making in how the faculty promotes its undergraduate courses to school students and so increase enrolments of a diverse range of top students.

The major issues usually addressed are:

- significant marketing activities that draw students to engineering courses
- major influences on students as they make their choices about engineering as a career
- result variations for atypical groups - women vs. men; city vs. country, different socio-economic groups or cultural groups
- why some students with adequate abilities and suitable backgrounds do not choose engineering as a career option - is it just personal choice, or lack of information?

There are many school students, both male and female, who do not choose engineering as a

career but who are intellectually capable and appear to have appropriate backgrounds and interests. If this career decision is an informed decision then we must just accept it, but if the decision is from ignorance or misunderstanding of the engineering profession then we must address this problem.

## INITIAL RESEARCH

To find out why our students at the University of Technology Sydney (UTS) chose engineering and what the major influences were, two questionnaires were given to two different groups.

In October 1999 a questionnaire was mailed to all current undergraduate engineering students at UTS (2700, 295 returned). From the results of this questionnaire some modifications were made to the questions for clarification before sending out a new questionnaire to all first year students attending the Orientation Camp at the beginning of their university experience in 2000 (325, 228 returned). It was expected that the results of this

questionnaire would differ from the first because this second set of students would have a fresher memory of their reasons for choosing engineering and UTS, whereas most of the previous group would be answering from a more reflective standpoint. From the results the influences on decision-making were analysed. The complete results are discussed fully in a report to the Engineering Faculty at UTS.

One set of data that is significant for the engineering profession as a whole is from a question that asked 'Where and when did you hear about engineering as a career?'

The answers given to 'when' they heard about engineering was Year 11, by a significant majority ( $\chi^2 = 96.59$ ,  $p < 0.001$ ). In answer to 'where', the response showed that 'parents and adult friends' (82%) was significantly higher ( $\chi^2 = 249.41$ ,  $p < 0.001$ ) than careers advisers who were next most popular (32%). Other options had lower returns.

However, a contradiction or paradox seems to arise: If parents and adult friends have most influence on students (and presumably were there throughout the life of the student) why does Year 11 feature most prominently in answer to 'when', and not primary school?

Perhaps one explanation is that when answering questionnaires of this nature it is difficult for students to work back to find the first step in the sequence of events that caused them to eventually choose engineering as their career path. Although, in the students' minds, parents and adult friends played a significant part in the decision-making process, were they talking to their parents because of something they were told by their careers adviser or read in a leaflet? Was it because of something they had heard in primary school that eventually led them to choose subjects in Year 10 that in turn led them to consider engineering in Year 11?

The question remains, when do students develop the familiarity with engineering needed to begin their consideration of it as a career path? If this is as late as Year 11 then what can be done about it? If it is earlier, what is in their understanding to then exclude engineering as a career choice? If it

is as late as Year 11 should universities be concentrating their marketing efforts just on Year 11 students or trying to develop awareness at an earlier age?

Another interesting result from the analysis was that the answers were almost identical for our male and female students. Does this further reflect the lack of diversity in the type of student attracted to engineering?

Having had many years experience in the education of young women at high school level, we feel that one major stumbling block to student diversity is a lack of understanding amongst school students, teachers and parents of the role of engineering in society. Unlike many other subject areas in the school curriculum, '*engineers don't teach and teachers are not engineers*' [10].

A book review for a resource book for teachers by Shallcross [4] claims that '*... most secondary school **mathematics teachers do not have an appreciation for engineering discipline. Teachers often are not aware of the diverse opportunities that the engineering profession offers their students.***' [14]

Hofman [9] notes that '***Children form predominant attitudes before age nine ... attitudes developed in elementary school affect choices made in high school and as an adult.***'

Rinehart and Watson [11], in conducting a survey to determine why women selected engineering found that twice as many women as men reported that a teacher or councilor encouraged them. Draughn and Rinehart [8], setting the scene for the High School Outreach Program at Texas A&M University, report finding data that show that '*Americans feel less well informed about engineers and engineering than they do about science and technology.*' In her research into why women enter engineering, Blaidisel [7] found much data to support the theory that '***Female high school students are often unaware of what engineering is, the variety of options within engineering, and the socio-economic benefits of being an engineer.***' Even outside the engineering field, this hypothesis of articulation is supported. Williams [5], an author and designer states that naming a concept and thus becoming familiar

with it is the first step to development of understanding. In a study of factors affecting career choice of women in engineering Smeaton [12] found that: *‘Due to lack of experience, and/or lack of knowledge, one of the main tools available to students for judging an interest in an occupation is whether or not it is seen to be maths/science-related or humanities-related... Respondents who thought that engineering was a profession that would help people were more likely to nominate it on their tertiary entrance forms.’*

Commentators within engineering have observed that engineering courses seem to be attracting the wrong people and producing the wrong sort of graduate to meet the needs of 21st century Australia [1] [15]. Despite the academic emphasis on mathematical ability and reasoning, employers are also interested in communication skills, teamwork, learning skills and awareness of economic, environmental and social aspects of engineering work [2].

Engineering faculty programs to educate high school students about careers in engineering usually target senior high school students with strengths in maths and physics. These programs must broaden understanding of engineering in the 21<sup>st</sup> Century. As Adelman [13] states - *‘Neither women nor men will choose engineering for the right reasons unless the profession can reach out to a broad population with a full portrait of the richness of its culture and practice, and with a clear map of its intersections with and divergences from bench science.’*

Our hypothesis is that unless young people and their teachers have direct contact with engineering through family or friends, they may never have articulated the word ‘engineering’ until they are expected to make career choices or guide students in their choice. This then affects the student diversity and intake attributes of students in engineering courses.

## SUPPORTING RESEARCH

Thus the subject of our recent research is to verify the claims from literature for Australian students and answer these questions:

- When do students begin to articulate the word ‘engineering’ (i.e. talk about engineering with their peers)? That is, **when do they become aware** of engineering as a career option?
- **Is this early enough** to make informed subject choices to continue into the engineering career path at the end of high school?
- **Is their understanding of engineering valid** for the 21<sup>st</sup> century engineering profession?
- Do current efforts in promoting engineering at UTS **target the appropriate audience** and issues?
- By addressing these questions, are more students then going to choose engineering as a career path?

In a recent Capstone Project on ‘*High School Students’ Perceptions of Engineering*’ [3] the literature review highlighted some major issues that affect student diversity in Engineering:

- Negative perceptions of engineering are well established by the end of primary school.
- Careers education is a resource for students to learn about careers they view positively not to correct negative perceptions.
- Maths is the critical filter for careers in MSE (Maths, Science and Engineering) yet by the time students are aware of this they are often already ‘out of the loop’ for these careers by not studying maths at the required level.
- Engineering outreach programs for Years 10-12 can be used to reinforce positive perceptions and counter negative perceptions in students already committed to careers in MSE. They are of limited use correcting negative perceptions in students not committed to these careers.
- Negative perceptions of maths and science are issues for engineering and reduce the likelihood that K-12's (Kindergarten to Year 12) perceptions of engineering will be altered.

To verify these findings from literature for Australia and examine our high school students’ perceptions of engineering two surveys were carried out. The focus of the first survey was ‘perceptions of engineering’ and the second ‘articulation of engineering’.

Our expectations from these surveys were that:

- students who had identified with engineering as a career option would have a perception of engineering that reflects the current profession
- engineering would not feature in 'top-of-mind' jobs, especially in the younger students
- articulation and perceptions of the engineering profession would be poorer in the younger students.

Contrary to our expectations, there was a congruence between perceptions of engineering in all students. A larger percentage of younger students were 'not sure' about many of the statements describing the profession or the personality of engineers. However, the extremely negative stereotypical view of engineering that might be expected in a group with limited exposure to engineering careers information was common to all students.

'Top-of-mind' jobs listed by students in Years 7-9 were as expected: architect, doctor, lawyer, nurse, shop keeper, teacher. In the next group (listed <25% of of the time) were accountant, carpenter, engineer, police officer and secretary. The older students did list engineer more often. However, this result could have been due to the class selected to be surveyed.

When matching jobs with understanding of the work involved none of the younger students showed an understanding of engineering. Many of the older students scored well in understanding of engineering work. Again, was this an anomaly of the environment in which the survey took place? More research is needed to verify these results.

## DISCUSSION AND RECOMMENDATIONS

Despite a few anomalies, the results from our research with NSW high school students suggest that they do not have sufficient understanding of engineering to make an informed decision about what careers in engineering - if any - are compatible with their personality, academic ability, intelligence, communication style, learning style and values. From the research and the literature it becomes apparent that problems with student diversity and decreasing enrolments in engineering in Australia can be attributed to:

- negative and outdated perceptions of engineering in students, teachers and parents, that leads to
- exclusion of engineering as a career option before informed decisions are developed at senior school level through careers education or university promotional activities.

Although there is no doubt that the role of engineers is changing, and that both society and business now hold different expectations of engineers than ten or twenty years ago, the profession is struggling to communicate these changes to school students and/or their teachers and parents. While students' perceptions may be slowly changing, they are not changing quickly enough. How can engineers and engineering educators facilitate this change in perceptions?

## Increasing Student Diversity

There is already diversity within engineering in terms of industries, jobs, projects, working environments and achievements. Perhaps the best evidence that school students do not understand this is the lack of diversity (women, ethnic minorities and 'non-traditional males') in the engineering workforce and in engineering faculties. (Non-traditional males include any male students who do not fit the mould of the stereotypical male engineer.) The common perception that engineers are a homogeneous group of men with predictable careers, limited interests and values, building bridges, is inaccurate and outdated. Attempts to reverse this perception have met with varying levels of success, or failure, and their impact on increasing enrolments and progression appears to be minimal.

**Recommendation 1** – that engineers and engineering educators **encourage** a workplace inclusive of a diverse range of professional engineers (women, 'non-traditional' males and culturally diverse engineers) at more than just lip-service level and develop ways to **promote** this positive image to the **broader community**.

## Broadening Intake Attributes

At present, the audience for promotion of engineering is senior high school students who are committed to a career in MSE. The

underlying assumption is that students who are not committed by senior secondary level to careers in MSE are not capable of a career in engineering. As found in the research and literature, this is certainly not the case. However, because of negative experiences with maths and science and failure to see their relevance, capable students achieve poorly or stream themselves out of engineering career options later.

**Recommendation 2** - when promoting engineering options to school students the breadth of the audience must be expanded to include **younger students**, before they stream themselves out of engineering options.

### Public Perceptions

Engineers are rarely seen in the public spotlight. While many engineers prefer to let the quality of their work speak for itself [16] the reticence of the profession leaves the general public ignorant of the breadth and depth of engineering innovation, knowledge and expertise. Individual engineers may prefer to remain invisible, but with no well-known engineers in the media, popular fiction or entertainment, it is almost impossible to eliminate the perception that the typical engineer is either a nerd with no social skills, or a motor mechanic, or a train driver.

The ability of writers, journalists and commentators to articulate engineering also matters greatly in maintaining the prominence and status of the profession. Many articles about engineering issues fail to include the words 'engineer' or 'engineering'. A recent search found some excellent examples of inaccurate and sometimes damaging media about engineering [3]. The lack of good writers and journalists with a background in engineering is not the only barrier to the profession's representation in the media. Even when engineers can communicate engineering well, their message sometimes becomes lost in the medium [6].

**Recommendation 3** – that the engineering profession use **appropriate strategies and media** to present 21<sup>st</sup> Century engineering to the public in **positive, well articulated messages**.

### FUTURE DIRECTIONS

These three recommendations address changing community perceptions of engineering, but how this is to be done and who should do it are two big issues.

**Universities** are actively promoting engineering as a career option. They spend large sums promoting engineering as a career option to Year 11 and 12 school students. However, in the current economic climate, it is seen as more immediately cost-effective for faculties of engineering to encourage 'brand-switching' from customers who already want to purchase the product (engineering). To change overall perceptions of potential students and families and encourage them to 'buy' a product for the first time and so choose engineering is more difficult and thus more expensive.

Universities focus on the last two of the three steps in the process:

1. informing, influencing and changing perceptions of engineering as a profession
2. informing, influencing and changing perceptions of engineering education providers
3. informing, influencing and changing perceptions of particular disciplines of engineering,

It is paramount that in doing so, universities do not reinforce old perceptions by promoting engineering in terms of engineers of the past, but in terms of the new breed of engineers needed in the 21<sup>st</sup> century.

The **engineering accreditation bodies and professional associations** (e.g. Institution of Engineers Australia) are also aware of the problems facing the profession and act positively to address these problems. Through efforts like the Neighbourhood Engineers program, teaching resource development and video and media productions these groups have the opportunity to change perceptions. It is paramount that these efforts do not reinforce old perceptions and focus on the interests and needs of the audience rather than the needs of engineers to tell their story.

**Teachers** have the opportunity to relate their subjects to real-life engineering examples but

many are not familiar with the profession so are unable to make such links. Programs like the EngineeringLinks program at UTS are trying to address this problem.

**Engineers themselves** also have an important role to play in changing community perceptions. The ability of engineers to articulate effectively what they do, and how they do it, both collectively and individually, is essential.

## CONCLUSIONS

Given how little students know about engineering and how many students have no identifiable aspirations or career plan, it is unrealistic to think that an advertising campaign or a visit to a careers night will make any difference. If the word 'engineering' is not in regular use in the media, in classrooms and in everyday conversation, school students cannot learn to articulate what it means to be an engineer and the role engineers play in society in the 21<sup>st</sup> Century is misunderstood.

A concerted effort by all stakeholders in the engineering profession must be made to communicate the importance of engineering to society and the rewards of pursuing a career in engineering to school students, to reverse the decline in interest in engineering and encourage student diversity. If engineering remains an invisible or misrepresented profession, how can young children and their parents and teachers ever become better informed?

What can we do to change perceptions?

## REFERENCES

1. IEAust (Institution of Engineers Australia), *Changing the Culture: Engineering Education into the Future* The Institution of Engineers, Australia, Canberra (1996)
2. Rayman, P, and Stewart, J., 'A New World: The Terrain for Women in Engineering' Tackling the Engineering Resources Shortage: Creating New Paradigms for Developing and Retaining Women Engineers Bogue et al (eds) SPIE, USA, (1999)
3. Scanlon, C *An investigation of High School Students' perceptions of Engineering* Capstone Project, University of Technology Sydney (2002)
4. Shallcross, D *Investigative Projects in Engineering: Designing a bulk liquid chemical storage facility.* University of Melbourne Faculty of Engineering & Mathematical Association of Victoria (2000)
5. Williams, Robyn *The non-designers design book.* Peachpit Press: California (1994)
6. Ahearn, A., 'Words Fail Us: the Pragmatic Need for Rhetoric in Engineering Communication' *Global Journal of Engineering Education*, Vol 4., No. 1, pp 57-63 (2000)
7. Blaidsell, Stephanie Students' decisions to enter engineering: how men and women differ. *Proceedings of the WEPAN 2000 National Conference, Second Stage Transformations*, Washington DC June 25-27, pp 243-251 (2000)
8. Draughn, Patricia and Rinehart, Jan High school outreach program (HOP). *Proceedings of the WEPAN 2000 National Conference, Second Stage Transformations*, Washington DC June 25-27, pp 153-157 (2000)
9. Hofman, Helenmarie Engineering as a career choice: strengthening the weakest link. *Proceedings of the WEPAN 2000 National Conference, Second Stage Transformations*, Washington DC June 25-27, pp 137-143 (2000)
10. Jacobs, B. Engineering links - when engineers don't teach and teachers don't engineer *Proceedings of the WEPAN 2000 National Conference, Second Stage Transformations*, Washington DC June 25-27, pp 199-204 (2000)
11. Rinehart, J. and Watson, K. A campus climate survey at Texas A&M University. *Women in Engineering Conference: Creating a Global Engineering Community through Partnerships*, June, pp 93-99 (1998)
12. Smeaton, Belinda Women in engineering: an examination of factors affecting career choice. In *Proceedings of the Third Australasian Women in Engineering Forum - Finding the challenge in change: choices for women in engineering.* Dec 1996 University of Technology: Sydney p 60 (1996)
13. Adelman, C. *Women and Men of the Engineering Path: A Model for the Analysis of Undergraduate Careers* US Department of Education and the National Institute for Science Education [<http://www.ed.gov/offices/OERI/PLLI/pubs-postsec-engineering.html>] (accessed 2002, February 2) (1998)
14. AAEE, Australasian Association for Engineering Education *Australasian Association for Engineering Education Newsletter* December (2000)
15. Copeland, J., and Lewis, S., 'Working With Men to Change The Culture of Engineering Education' [<http://www.adelaide.edu.au/equity/reports/archives/workingwith.html>] (1998)
16. Yates, A., Discussion Paper on Raising the Status of Engineers The Institution of Engineers Australia, Sydney (2000)