
*Focus Groups for informing AWPAs Engineering
Workforce Study 2014*

Final Report

Daniel Edwards, Jacob Pearce, Kate Perkins and Justin Brown



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Finally, the project team would like to thank the engineers and students who participated in the focus group sessions and provided the rich insights that form the findings of this report.

EXECUTIVE SUMMARY

The Australian Workplace and Productivity Agency recently stated: ‘After years of shortages in critical engineering skills in Australia, the overall supply of engineers has gradually increased. However, there still remain significant areas of concern relating to future engineering demand, supply of future engineering services, and barriers to workforce participation by under-represented groups.’ (AWPA, 2014, p.9). In order to better understand these issues, AWPA are conducting a national study exploring the engineering workforce. As part of this wider project, the Australian Council for Educational Research has been engaged by AWPA undertake a series of focus groups. This project report provides details and findings from this qualitative data collection.

The project detailed here involved the development, coordination and implementation of focus groups, and the reporting of outcomes in a way that generates first-hand information about the experiences and attitudes of the following specific groups of people in relation to the engineering labour market – women, mature-age workers and new graduates. The work here also explored the views of the next generation of engineers, gathering information from senior school students about their perceptions of the engineering workforce.

The aim of these focus groups was to provide some nuanced dialogue about the issues being faced in the engineering workforce that would help to inform, expand and corroborate the broader and more representative quantitative analyses that are being undertaken in the main AWPA study.

Eight focus group sessions were held across Australia during April and May 2014. Each session focussed on one of the four target populations – women in engineering, mature-age engineers, recent graduate engineers and senior school students. In total 67 people participated in the focus groups.

The main findings from the discussions with these groups are outlined below.

Women in engineering

- The educational experiences of these women were positive, and there was a strong sense that at university they did not want to be treated as ‘special’ because they were a minority.
- Being a woman was not seen by participants as a barrier to securing employment as an engineer. In fact in general it was suggested that currently, being a woman was potentially likely to increase employment prospects in engineering.
- However, the participating women suggested that females were not necessarily as well remunerated as men were within the engineering workforce. With a suggested reason for this being that women do not ‘rate’ their worth (salary-wise) as highly as males do, and as such are missing out when salary negotiation occurs.
- While participants identified significant progress in gaining employment, conditions for maternity leave and working part-time, they also believed that there remains an underlying ‘old school’ culture in many parts of the engineering workforce that hinders progression and opportunities for women.
- Linked closely to the previous point is the underlying belief of participants that there exists an attitude that you ‘can’t be both a good mother and a good engineer’.

Mature-age engineers

- Opportunities for engineering work in Australia have changed in the time these participants have been in the workforce. Government as a major employer of engineers is long past, and with this the demise of cadetships. The era where you could serve one company for your whole career was an era in which many participants began their engineering careers, but it was widely recognised that this is no longer a common experience.
- The current era is seen by some participants as more focused on a highly specialised set of jobs, less rotation of workers to broaden an individual's range of expertise, and less mentoring.
- Participants believed that rapidly changing industry is altering demand for engineering skills. For example the manufacturing downturn in Australia means a wide range of skills are no longer needed. Therefore, those with such expertise have to either change industry or follow the manufacturing and go overseas.
- There is a feeling that the growing emphasis on management rather than technical skills in engineering is misguided and detrimental to the future of the workforce and the economy.
- Mathematics is crucially important to engineering, yet there was a strong feeling among participants that it is being left out as a prerequisite for entry to university courses and is not encouraged strongly enough in schools.
- There was recognition that universities have to cover such a wide range – technical, theoretical, soft skills, business acumen, work integrated learning, practical application...and at the same time are (unreasonably) expected to produce 'work ready' graduates.
- The participants in the mature-age focus groups saw the importance of the role of industry in 'educating' young engineers as vital. This industry role needed to be played for current university students as well as new graduates. Focus needed to be in skills above and beyond the theory that is taught at university and this could be facilitated in many ways, including strong mentoring programs.
- These senior engineers see that times are difficult for new graduates and acknowledge the difficult situation new graduates in engineering face in the current engineering workforce. They highlighted the focus of many engineering employers on hiring people with solid work experience and specialisations – the likes of which very few graduates have when they leave university.
- Participants in general believed that the contribution of engineers to the economy is not well recognised by Australians. The consensus was that engineers are undervalued and that creativity and problem solving were not seen as key tasks of engineers – despite these two areas being fundamentally what engineering is all about.
- While there is overall optimism about the future of engineering workforce in Australia, there is caution about becoming 'project management' focused at the expense of developing the important technical skills required by engineers.

Recent engineering graduates

- According to graduates involved, the decision to pursue engineering was generally related to interest in and aptitude for mathematics – and recognition of the links between mathematics and engineering occupations.
- For many of the participants, their understanding of and interest in the engineering workforce was developed through following the experiences of family members who were engineers.

- For others, interest in engineering was sparked through participation in hands-on activities initiated by university engineering departments and aimed at middle-to-senior school students.
- The transition from school into university is critical, and the experiences of participants were quite variable – some feeling out of their depth in the early years of study, while others felt there was not enough challenge.
- In general, graduates believed their courses were overly theoretical and could have been more practical.
- However, there was some difference in the theory/practice balance experienced by graduates at university, with those from the more research-focused institutions experiencing a heavily theoretical oriented course, while those from more technical-based institutions having a more in-course practical experiences.
- Without doubt, the self-organised work placements (or vacation work) undertaken by the graduates during their university studies was considered seminal in workforce preparation and in providing an entrance to employment on graduation.
- However, graduates highlighted the difficulties and complexities in gaining placements. While those involved in the focus groups were the ‘success stories’, these graduates described the arduous task of applying for placements – with a rigorous processes, similar to applying for their first jobs as graduates.
- Experiences in gaining work as a graduate engineer was relatively positive for this successful group of graduates, although approaches taken did differ. Some gained work following ‘blanket’ application to dozens of employers, others gained their first job directly through placements they had undertaken during university study.
- For those following the ‘graduate position’ path into the workforce, there was a feeling that in the big engineering companies, the application process was a bit of a ‘black box’, and new graduates found themselves competing for work with engineers with more experience.
- In general, graduates tended to think that their employers were supportive of them as new engineers and that workplace expectations were realistic. Most of those involved could see clear pathways in the future with their employer – although there was a clear example of more precarious employment for one participant.
- Graduates were generally positive about the culture of their workplaces, although there was some cynicism about the prevalence of ‘politics’ within the workplace and the extent to which this might impact on prospects for career advancement.

Senior school students

- Overall, senior school students involved in the focus groups were relatively well aware of what engineering is and what engineers do. In some cases the wide variety of roles for engineers was very well understood.
- Many of the students knew about engineering through family members who were engineers. A few also knew about it through participation in school and extracurricular careers activities.
- A strong link between interests in (and aptitude for) mathematics was identified by school students.
- A particular appeal of engineering highlighted by students was the real life problem solving aspects of engineering occupations.
- Awareness of the educational pathways required to enter the engineering workforce were broadly known by students, although some of the detail relating to entrance, length of courses etc. was less well understood.

- Careers advice and booklets provided to students were not seen as very helpful, instead the experiences of the students suggest that real engagement is more visceral. As such the inclusion of hands-on, visible activities, and role models (family members) in engineering are important for sparking an interest at this level and earlier at school.

1 Introduction

This report highlights the findings of a project undertaken by the Australian Council for Educational Research (ACER) for the Australian Workplace and Productivity Agency (AWPA) that will contribute to a wider study of the Engineering Workforce. The project involved the development, coordination, implementation of focus groups and the reporting of outcomes in a way that generates first-hand information about the experiences and attitudes of specific groups of people in relation to the engineering labour market – women, mature-age workers and new graduates. The work here also explored the views of the next generation of engineers, gathering information from school students about their perceptions of the engineering workforce.

AWPA have recently identified that: ‘After years of shortages in critical engineering skills in Australia, the overall supply of engineers has gradually increased. However, there still remain significant areas of concern relating to future engineering demand, supply of future engineering services, and barriers to workforce participation by under-represented groups.’ (AWPA, 2014, p.9). There are numerous studies into issues faced by such groups, which have driven the need to further explore what is happening in the Australian Engineering Workforce, and develop means of improving access to and retention in the sector.

For instance, in 2011, across all OECD countries an average of 14% of women entering the higher education sector enrolled in STEM (science, technology, engineering and mathematics) related courses, compared with 39% of men (OECD, 2014; Acheron, 2014). While there is a disparity here in terms of gender, another factor is how appealing careers in the Engineering Workforce are for students. Myers has argued that ‘It is possible for industry to effectively sell the value of engineering as a career path to students. It is also possible to sell the engineering profession as an important part of our Australian society to the community at large’ (Myers, 2012, p. 20).

Barriers also exist once students graduate from their studies. For instance, first year graduates in a 2009 survey indicated that they were expected to use employability skills much more in the workplace than their studies had prepared them to do (DEEWR, 2009). At the other end of the spectrum, there are issues relating to retention of women and mature-age workers in engineering, who may face barriers to their profession due to compounding factors outside of work, or due to the changing landscapes of the engineering industries.

This project involved a series of focus groups with engineers and potential future engineers to explore their experiences and perceptions of the workforce in which they are situated, the educational pathways to engineering and issues and barriers to participation and career advancement. The findings here will contribute to a wider study being conducted by AWPA. As such, the aim of these focus groups was to provide some nuanced dialogue about the issues being faced in the engineering workforce that would help to inform, expand and corroborate the broader quantitative analyses that are being undertaken.

This report details the findings of this research project. It begins by highlighting the terms of reference, and then provides an overview of the methodology employed, engagement with stakeholders and participants. The core component of the report focuses on the dialogue of the four target populations in relation to the study – women in engineering, mature-age engineers, new engineering graduates and senior school students.

1.1 Terms of Reference

This project is guided by the terms of reference as set out by AWWPA. These terms of reference are stated below:

1. Convene a total of eight focus groups in Sydney, Melbourne, Perth and Brisbane during March to April 2014 to generate primary data on participation, engagement and retention of women and mature-aged workers in the engineering workforce and on factors influencing secondary students' and recent engineering graduates' career choices at school and tertiary education levels, divided into two focus groups each for the following categories:
 - women in engineering (university students, professionals and engineering technicians and trades workers);
 - mature-aged workers (engineering professionals and engineering technicians and trades workers);
 - students (Years 10 and 12)—both boys and girls should be equally represented in this group; and
 - first year engineering graduates (including women).
2. Ensure that focus groups for each participant category are held in different locations. For example, one focus group for women could be held in Sydney and the other in Melbourne.
3. Ensure focus groups comprise 10–12 participants each.
4. Ensure participants include key individuals relevant to the topic as well as relevant members from the community. For example, in relation to women in engineering, the group should include local representatives from women in engineering peak bodies as well as community members who are women engineers. Where possible and relevant, the group should have a demographic and cultural mix.
5. Ensure focus groups involve semi-structured group interviews with participants, so that responses are followed through on issues as they arise.

2 Methodology

2.1 Population Definitions

As noted above, there were four main groups of focus in this project. At the beginning of the project, the four groups were defined by the project team and AWPA. The definitions below were used to inform recruitment of participants in the focus groups conducted for the study. These definitions detail the *desired* breadth of the populations for the focus groups. As detailed in the section on engagement and recruitment (section 2.4 below), while focus groups were carried out for each of these broad populations, the full breadth outlined below as not necessarily covered in the final yield of participants in the focus groups.

2.1.1 Women in Engineering

This group consists of women who are involved in engineering through either:

- their current occupation (including engineering professionals, engineering technicians and engineering trades workers); or
- their current study (including higher education and VET engineering students).

2.1.2 Mature-age engineers

This group consists of males and females aged 45 and above who are employed as engineering professionals, engineering paraprofessionals, engineering technicians or engineering trades workers.

2.1.3 Students

This group consists of secondary school students (males and females) from Year 10 to Year 12. A specific focus will be on students who are studying in or have shown particular interest in areas of science, technology, engineering and mathematics (STEM).

2.1.4 First year engineering graduates

This group consists of males and females who completed a higher education or VET engineering qualification in 2013.

2.2 Caveats

This project is one part of a wider body of work contributing to a broader study of the engineering workforce in Australia. At the outset, it was highlighted that there were serious limitations to this particular study in regards to timeframes, sampling and the levels of representation that might be gained in the project. These limitations were acknowledged early on in the work, and while they exist, were not seen to significantly compromise the overall aims of this project, which is to collect some nuanced insights and rich qualitative data about the experiences of individuals in relation to engineering work that will add some narrative to the broader quantitative and policy analysis that will be included from other parts of the broader study being conducted by AWPA. Some of the specific limitations to the focus group work are discussed below in order to contextualise the outcomes that are detailed in this report.

The engineering workforce in Australia is large and diverse. In this project, the sole data collection was through qualitative focus groups consisting four particular populations in four specified cities. The participant population was entirely based on a convenience sample,

based on who is available and interested, who fits the population, and where the focus group was held. While this project has provided nuanced insights into the engineering workforce, it has not yielded a representative sample of opinion either from the populations of focus, or by discipline, occupation, age, career stage or other characteristics.

Accordingly, while the insights gained from this project will contribute substantially to the detailed quantitative work being conducted for AWPAs wider study, they do need to be included with a caveat that they are offering the opinions of particular individuals at a particular point of time and location and therefore may not necessarily apply across the more generalised population or the engineering workforce as a whole.

2.3 Framework for focus groups

In order to inform this project and develop a foundation for the focus group conversations, a framework was developed by the project team. In establishing the framework, the project team consulted relevant literature, policy documents, and existing background work done by AWPAs. The framework and subsequently discussion plans were informed by key elements of several existing pieces of work. The most relevant is the *Engineering Workforce Issues Paper* (AWPA, 2014). A specific framework document was provided to AWPAs during the project as a specific deliverable. This section of this report outlines the key areas of the framework in order to provide some context for the discussion in the findings section of this report.

The framework is summarised in Table 1. It identifies three broad career stages of the existing and potential engineering workforce (first column). It then identifies further detail/nuance within each of the broad stages through education-type and career timeframe (column two) and type of work (column three). Within each broad career stage, some core issues relating to the engineering workforce are identified in the fourth column. The fifth and the final columns offer some contextual dimensions to be considered that potentially span all stages of the career lifecycle identified here. These include factors that constrain or encourage participation/success and also the ‘lens’ or ‘filter’ that shape understanding of, and responses to, the issues addressed in the focus groups. These contextual factors are important pieces in interpreting the responses of individuals during the focus group sessions and contextualising the overall responses gained through this project so as to be aware of potential biases, or limitations of the population participating in the focus groups.

The framework in Table 1 facilitated the development of detailed discussion plans for each of the eight focus groups undertaken in the project. These discussion plans included specifically worded questions designed to stimulate conversation among the participants, while also allowing facilitators to be flexible in guiding discussions. Discussion plans were designed ensure a level of consistency across the eight focus group sessions conducted. Each of the discussions plans followed some or all of the following core elements. These elements are also used to guide the discussion of the findings in the next section of the report:

1. Overview and introductions
2. Educational pathways to engineering
3. Commencing in the engineering workforce
4. Reflections on engineering work
5. Progression and advancement in engineering
6. The future of engineering

Detail of the specific discussion plans for each of the populations can be found in the Framework document developed early in the project.

Table 1: Framework for Engineering Focus Groups

1	2	3	4	5	6
Broad career stage	Detailed career stage	Broad work function	Core issues	Constraining/encouraging factors	Lens
Education	School	Para-Professional	<ul style="list-style-type: none"> What is engineering? Clarity of pathway to engineering workforce Desirability of engineering workforce Work Integrated Learning (WIL) 	Cultural (both social and within workplace) Economic Family Other	Occupation Discipline Industry Location Gender Age
	VET	Technicians and Trades			
	University	Professional			
Career commencement	HE graduate	Professional	<ul style="list-style-type: none"> Accessibility Competition Link between education and current occupation (incl WIL) Salary and remuneration Employer expectations Issues in securing work Support networks 		
	VET graduate	Para-professional Technicians and Trades			
Progression	Early career	Professional	<ul style="list-style-type: none"> Accessibility Competition Discrimination Salary and remuneration Education and Professional Development Support networks 		
	Middle career	Para-professional			
	Later career	Technicians and Trades			

2.4 Engagement and recruitment

2.4.1 Overall approach

Due to the relatively short timeframes in the project, the approach to engagement and recruitment for the focus groups needed to be succinct and as efficient as possible. The first part of this section outlines the overall approach applied in this project, with subsequent parts providing specific detail about each focus group organised. Overall, two broad approaches were followed – one for the engineering workforce groups (women, mature-age and graduates) and one for the school students.

From the outset, Engineers Australia were identified as a key group for the workforce groups – not only in terms of the significant membership base they have in the engineering workforce, but also because of their access to suitable venues equipped for workshops and familiar to engineers in the cities in which the focus groups would be conducted. As such, personnel at Engineers Australia were contacted at the beginning of the project to establish a

relationship and to begin to identify ways of identifying key groups, and find key dates, times and venues for undertaking the focus groups.

In practice, the main points of contact with Engineers Australia occurred at the State Division level within three main members groups – Women in Engineering, Young Engineers and the Centre for Engineering Leadership and Management. As contact was made with relevant people in each of the states for these three key groups, discussions about timing and venues took place. Once venues and times were settled, digital fliers advertising each session were distributed to mailing lists by relevant contacts at Engineers Australia.

At this point, the ACER project team widened the stakeholder contact base, sending fliers advertising the focus groups to a wide range of other groups (detailed further in the individual population sections below).

The approach to recruiting school students was undertaken in parallel to the recruitment of engineers and is detailed in the schools section below.

In all sessions, participants were provided with plain English statements explaining the project aims, assuring participants that their confidentiality would be maintained in any reporting of the sessions and providing contact numbers for the project team. Participants also signed consent forms to acknowledge their willingness to participate in the focus group.

2.4.2 Women

Focus groups for women were held in Brisbane and Perth. In both cases, the promotion and recruitment for these focus groups was coordinated through the respective Women in Engineering groups through the state divisions of Engineers Australia. In both cities, the chair of the Women in Engineering groups had personal involvement in contacting members and encouraging participation. The enthusiasm and commitment of these Chairs was commendable and involved phone calls with the project team and multiple emails and phone discussions with colleagues as part of recruitment.

Recruitment was primarily done through the distribution of fliers for the sessions via email to targeted participants through the Engineers Australia Women in Engineering Chair. In both Brisbane and Perth, the people involved in the recruitment were able to send the fliers advertising the sessions to a wide range of women in engineering – encapsulating the defined population of focus. For the Perth group, the flier was also sent to the National Association for Women in Construction, Western Australia for distribution among their membership. The focus group sessions were held at the respective state Engineers Australia headquarters.

Overall, 13 women across the two cities participated in the specific women in engineering focus groups for this project (note that there was additional female participation through the graduate, mature age and school groups). These women provided a range of experiences and opinions. The overall yield for this group was smaller than hoped. Feedback from the women involved suggested that the short period for advertising the sessions (a product of the tight project timelines) and having only one session in each of the two cities were likely inhibiting factors on participation numbers.

2.4.3 Mature-age engineers

Mature-age engineers focus group sessions were conducted in Brisbane and Sydney. In both these instances, the Centre for Engineering Leadership and Management (CELM) in the respective cities provided a point of contact. In Brisbane, initial recruitment was coordinated through the Engineers Australia office, with wider dissemination of advertising materials deployed by ACER to other stakeholder groups such as Consult Australia, Queensland Manufacturing Industry (QMI) Solutions, and the industry skills group Skills DMC. In Sydney, the sole recruitment was undertaken through the extensive mailing list held by the CELM. The focus group session was held at the Engineers Australia NSW headquarters.

Overall, 19 mature-age engineers attended the focus groups. A substantially large yield was achieved for the Sydney group, where 17 participants were present and the planned single focus group session became two sessions running in parallel. The substantially large turn-out for the Sydney session was in contrast to a less numerous group in Brisbane (2 participants). Given the similar (if not more extensive in Brisbane) recruitment approaches, the differences in yield here seems stark. The reasons for the differences are not clear. The Sydney experience suggested that the approach taken to recruitment did have the potential for success, but perhaps timeframes (Sydney had a couple of days more notice than Brisbane) and timing simply offered the mature-age engineers in Sydney a focus group with more convenient opportunity for participation that could not be realistically anticipated by the project team.

2.4.4 Recent Graduates

Graduate focus groups were conducted in Perth and Melbourne. As with the other groups, Engineers Australia was an important stakeholder in identifying appropriate dates for conducting the focus groups and in promoting the sessions widely to members. However, other avenues were also used to advertise the focus group sessions to participants – specifically through the educational institutions at which these graduates are now alumni.

For the Perth graduate focus group recruitment, the chair of the Young Engineers division for the WA promoted the session to all members through a personal email. Western Australian universities also sent email to alumni, with the University of Western Australia in particular emailing their large cohort of graduates from 2013. TAFEs in the Perth area were also contacted and asked to promote the session among recent graduates. The focus group was conducted at the WA Engineers Australia headquarters.

In Melbourne a similar pattern was followed, with Engineers Australia providing a large email distribution among Young Engineers members, while Swinburne, RMIT, the University of Melbourne and Box Hill TAFE specifically promoted the session to 2013 graduates. Other educational institutions (both university and VET) were also sent the digital flier advertising the event. The focus group session was held at the State Library of Victoria, in the middle of Melbourne's CBD.

Despite the substantial promotional efforts for the graduate engineer sessions, the two focus groups yielded a total of six participants. Explaining the low participation for this group is again difficult. It is possible that the timing of the sessions (sessions began at 5.30pm in each session) was too early – however, these times were made in consultation with Engineers Australia who host other activities at this time for Young Engineers. It is also possible that limited notice of the events reduced time to organise participation – both Perth and

Melbourne graduates had about one and a half weeks notice of the focus group time and venue.

2.4.5 School students

The approach to recruitment of schools and students was substantially different to that for the other groups in this project. Two schools were recruited to participate in the focus groups – an independent school in Sydney and a government school in Melbourne.

The independent school was identified following consultation and discussion with the NSW Association of Independent Schools (AIS). The AIS facilitated contact with the school and a visit from two of the researchers was arranged at a day and time to suit students. The school, a private boy’s school in Sydney, arranged for 15 students to take part in the session, the students were chosen based on their interests, with those who had specific interest or knowledge of engineering being the main participants.

The government school in Melbourne was identified by the research team as a potential site for focus groups due to the existence of a special academy for maths and science, as well as its active VET program. It is a large co-educational government school in the outer suburbs of the city. Accessing the school involved a lengthy process of application for research from the Victorian Department of Education and Early Childhood Development. Once approval was gained, the researchers and school leadership worked towards identifying an appropriate date for a visit to conduct focus groups on site at the school. Two sessions were conducted to specifically speak with different groups of students: a vocational stream; and a specialist maths and science program. In total 15 students from the school participated in the focus groups.

2.4.6 Session dates and participant numbers

In total, 67 people participated in the focus groups undertaken for this project. Table 2 provides an overview of the focus group sessions conducted. It details the focus population, date, city and participant numbers by gender.

Table 2: Focus Group dates and participants by group and city

Focus Population	Date	City	Participants	Male	Female
Women in engineering	3 rd April, 2014	Brisbane	8	0	8
Mature-age Engineers	3 rd April, 2014	Brisbane	2	1	1
Graduate Engineers	9 th April, 2014	Perth	3	2	1
Women in engineering	9 th April, 2014	Perth	5	0	5
Mature-age Engineers	10 th April, 2014	Sydney (two groups)	17	17	0
School students	11 th April, 2014	Sydney (two groups)	15	15	0
Graduate Engineers	16 th April, 2014	Melbourne	3	1	2
School students	12 th May, 2014	Melbourne (two groups)	15	13	2

3 Findings and key issues

3.1 Women in Engineering

Summary of findings:

- The educational experiences of these women were positive, and there was a strong sense that at university they did not want to be treated as ‘special’ because they were a minority.
- Being a woman was not seen by participants as a barrier to securing employment as an engineer. In fact in general it was suggested that currently, being a woman was potentially likely to increase employment prospects in engineering.
- However, the participating women suggested that females were not necessarily as well remunerated as men were within the engineering workforce. With a suggested reason for this being that women do not ‘rate’ their worth (salary-wise) as highly as males do, and as such are missing out when salary negotiation occurs.
- While participants identified significant progress in gaining employment, conditions for maternity leave and working part-time, they also believed that there remains an underlying ‘old school’ culture in many parts of the engineering workforce that hinders progression and opportunities for women.
- Linked closely to the previous point is the underlying belief of participants that there exists an attitude that you ‘can’t be both a good mother and a good engineer’.
- While there is overall optimism about the future of engineering workforce in Australia, there is caution about becoming ‘project management’ focused at the expense of developing the important technical skills required by engineers.

3.1.1 Participants

Women involved in engineering through either their current occupation or their study were invited to attend focus groups in Brisbane and Perth. In total, 13 women attended the sessions: eight in Brisbane and five in Perth. The women involved spanned a wide range of engineering disciplines, including civil, mechanical, chemical, process design, environmental, aerospace, project construction, geotechnical, computer, traffic, and engineering education. The Brisbane session included a current engineering student, and the Perth session included a first-year graduate. The women (apart from the student) had all completed a bachelor level qualification, and several had completed a Masters degree. One was a chartered engineer, and one was currently working at a university.

All (including the student) were currently working. However, one was about to go on maternity leave, and another was working part-time as she was the full-time carer of a child. Several were in the early stages of their career, while some could be classed as mid-career. Most were working in the field in which they graduated. Others had transitioned to other fields of engineering over the course of their career. The Brisbane group were all part of the Brisbane Women in Engineering group facilitated through Engineers Australia. The Perth group were also connected with Engineers Australia generally through the state’s Women in Engineering group.

As is clear from the description of participants here, the population for the Women’s focus groups was entirely university-qualified (or in the case of the student, soon to be university-

qualified). Therefore, compared with the desired population detailed earlier in section 2.1.1, the sample yield did not include women in engineering trades or women who gained their qualification through a VET pathway.

3.1.2 Educational pathways to engineering

Choosing engineering

Participants had typically made their decision to study engineering in the final years of secondary school. Many spoke with career counsellors and educational advisors about the types of jobs they would be good at (although, there were mixed opinions about the quality of advice from their career counsellors). Two participants even took aptitude tests which identified key professions. Most of the participants enjoyed mathematics, physics and other sciences at school and thought that engineering was a natural fit for them, even if it was a male dominated profession.

'I was always good at maths and science and it was always going to be engineering or medicine but I didn't want to spend my day working with sick people so I decided to do engineering.'

Some of the participant had initially begun following different paths to engineering. For example, one had wanted to be a teacher, but changed her mind at 17. Another had originally wanted to be a geologist and began a degree, but enjoyed the 'structural side' of the course, and went into the engineering stream. Some studied engineering with the idea that it would lead to other professions. One participant wanted to be a town planner, and thought that it would be a good idea to study civil engineering first. She enjoyed it, and never went on to complete the town planning qualification.

Another participant began studying engineering as a mature aged student, after originally planning to pursue a career in the medical sector but a friend of hers who worked at the Faculty of Engineering at the University of Queensland suggested engineering as a possible career path:

'My initial reaction was "Don't be silly!" but: I went to a talk given at the university called "Jobs for the Girls" where they had women of all different disciplines and stages of their careers and the underlying message was that if you like working with people, working with teams, problem solving and like maths, that Engineering was a good course for you. And so, I walked out of there going "Yep, this is what I'm going to do."

Some participants reminisced that they were actively discouraged to enter what was perceived to be a male dominated field. One participant had friends and acquaintances who said that maths and engineering were not really for girls, and perhaps teaching was a good option instead. However, there was a strong theme that parents (fathers in particular) influenced the women to study engineering.

'... you know I've had a lot of, sort of, friends who'd would say, and my personal experience too was they said "Oh, you're a girl... Umm... Maybe not Engineering, maybe not Maths; Teaching is a good option." Sort of on that ilk. And so again it was like my father and my father's friends, both female and male who were saying well "Yeah, yeah, go for it" and they were advising, you know, like you can always pick up French after university. Go for the hardcore, do Physics. You know, do your engineering now. Do what you can't do later.'

'My Dad ... was seeing all these young engineers come in, earn a lot of money travelling all around the state, doing really interesting jobs and so he's the one who sort of introduced the idea to me and I had no idea what engineering was.'

One woman claimed that in South Australia (where it isn't necessary to study mathematics at all in the final years of school) it's a fluke that any female engineers emerge at all.

'... particularly in South Australia where they don't necessarily encourage you to do any form of Maths in Year 12 or Year 11, it's almost a fluke that you get female engineers out of a South Australian curriculum.'

In terms of attracting women to engineering, this particular participant pointed to programs focused on attracting girls to engineering such as *Power of Engineering*, but she believed that programs such as this are not closely enough linked to school career counselling.

At the Brisbane focus group, there was a discussion about the reliability of school counsellors and group members expressed their belief that the career counsellor is often one of the weaker teachers, if even a teacher at all. There was a consensus view that a career counsellor does not have much knowledge outside the generic courses available at university, and popular ones such as Law and Medicine.

'I guess, unless you get really lucky in Australia, your Year 12 or your career advisor is normally one of the greatest duds of the school ... Most of them... if you wanted to do like Law or Medicine or something, very generic, they didn't really know a lot about anything else and it's very much like "Oh well...".'

Conversely, one woman who grew up in Iran was advised that her physics was good enough for her to enter the demanding field of engineering. The woman described being hesitant with this suggestion at first, but was convinced by an educational advisor that it was a good fit for her.

'... among the majors I could choose, my education advisor told me that "Okay, you have chance in engineering." First I thought it was, it's very demanding environment, at the start but then he talked me through it. Then I decided I'm going to be engineer; not necessarily mechanical, but I'd chosen engineering.'

In contrast to the Australian experience, one participant of Indian origin spoke about the cultural norm:

'I think it's also a bit of a cultural thing, like my family's Indian, so there's always that idea that, you know, a son or a daughter, they should do medicine or engineering.'

The focus group participants commented that their anecdotal experience showed that most women they knew who had entered a particularly male-dominated field had attended all girls' schools. In this way, these girls hadn't suffered a gender barrier at school. It was also pointed out that weak teachers affected both male and female students. However, one participant referenced a study that showed that women are more susceptible to believing other's opinions of them. So if women are told they're not good at something, they will suffer a loss of confidence.

Experiences of engineering education

When asked generally about their overall experience of engineering education, the women were extremely positive. *'Awesome. I loved it'* was a common thread. One participant mused

that going to university turned the fact that she was a minority on its head – and made it from a negative into a positive:

'You know, when you're at high school, you're the female Maths geek and you're really quite isolated and girls will pick on you and when you got to Engineering (at university) and there was a few other females, finally you found your little niche. Very happy.'

Another participant found that there was less of a gender barrier than she had expected at university. She described the 'camaraderie' that grew among the students who would all work together to solve problems and complete assignments:

'It was less of an issue than I thought I expected and I guess because when you're at uni, you're all together, this big group but it's kind of like you're all working the same problems of assignments and there's a bit of camaraderie and it's... I found that the gender wasn't really an issue but then there was heaps less of us...'

An environmental engineer highlighted that the female to male ratio in her degree was close to 50/50. She also stated that the environmental engineering male students were '*probably copping it from the other male engineering students*' due to their choice to study environmental engineering. This participant thought that the 'civils and mechanicals' probably thought that the work was tough and girls probably shouldn't be there.

'(There were) young guys that just, you know, thought they were really tough and that girls shouldn't necessarily be there. They're not going to say it but they sort of made you feel like that during workshops and things.'

Many participants referenced the drinking culture among the engineering students. Some found this difficult to deal with, and others thoroughly enjoyed it.

'The hardest things that I found were the drinking culture, cause I don't drink and so there was a whole lot of that and then I knew they had all these initiation things and I just stayed right away from that.'

However, there was no indication that the drinking culture was 'led' by males. It was just a part of being at university, and joining in with student societies.

Overall, the women involved in the focus groups expressed a strong sentiment that they didn't like being singled out *because* they were women.

Support during study

There was a discussion about the way some support groups can push the minority factor too far, which in turn sets female students up thinking that when they enter the workforce, they will be a minority and have to push and fight to make themselves heard. There was a general feeling that this might set up the wrong attitude in some of the female graduates.

As such, there were mixed views on the relevance and importance of support groups for women at universities. One woman rejected the idea of a 'womens' group'. She refused to participate in a specific womens' group '*because you're a minority*', preferring to frequent the Civil and Mechanical Engineering student societies which supported 'everyone'. Another participant mentioned that she did not mind the lack of specific support for women engineers because:

'I never think of myself as a woman engineer. I think of myself as an engineer.'

One participant described a fellow female student who sent an email around canvassing support for a female support group. Her response was *'as long as we're not considered hairy legged feminists and guys can join the group'*. One participant spoke about how the supports at university were always available, and the best supports were for students, regardless of gender.

However, the support groups were identified by some as being a good way for students to become involved in mentoring and other higher-level support programs. One focus group participant mentioned getting picked up for a useful 'Women in Technology' mentoring program after attending the female support groups.

Nevertheless, the participants generally agreed that the best support available while at university tended to be support from fellow students. It was noted that there was a sense of female solidarity at university: because there are so few females it is easy to get to know all of them.

'... what I noticed is say out of a year group of hundred... you would know all ten girls. You might know twenty guys and you might know ten girls and ten guys in the year above you and ten girls and ten guys in the year below you, so you were seeking out female companionship. You knew all the females; there weren't many and you did stick out like a sore thumb but you didn't know all the males... There was some sort of like peer supporting... like that the girls did sort of naturally I think.'

Interestingly, the way in which engineering is now being taught has begun to eliminate the issue of gender as a factor in classroom interaction. The current student spoke about the anonymising factor inherent in online studies. She did not have any idea about the male to female ratio of her fellow students because she interacts in online forums when she needs assistance, and has no way of telling who is male or female within the online environment.

Placements and internships

Most participants took initiative when they were students, finding summer jobs. Many worked with the mining companies, but others found other options. The participants stated that although these programs were not formalised when they were at university, most universities have now formalised these arrangements. According to one participant, this was a valuable experience because it showed the reality of life as a mining engineer. The consequence of seeing how engineering was in the 'real world' was that following placements, many students dropped out of university or changed course.

One participant found that doing an internship prepared her for the less interesting aspects of the job and removed the notion she had that she was:

'gonna go out and see the world and work on these big projects... and it's quite a shock to be a graduate and realise "Oh... lots of working isn't necessarily applying what I learnt in that lecture, but it's just learning the processes of this organisation and tapping into my knowledge every now and again."'

Another participant talked about the disconnect between the 'cutting edge' being taught at university and the *'safe, proven technology which is generations behind what the lectures were telling you about'* that is used in the workplace.

Other participants said that taking every opportunity at university to gain work experience helped in their transitions to an engineering career and that there were other students who

were lazier and probably had a shock when they entered the workforce. Interestingly, the decade the students studied in had an effect on the availability of student work, with one participant saying that studying in the ‘boom time’ meant that there were many undergraduates working in the field due to the high demand for engineers.

Some universities were noted to be better at preparing students for the workforce, while others were said to be more academic and not in touch with the real world. There was general consensus that the more vocational degrees prepared graduates better for entry to the workforce. One participant in Perth stated:

‘All my degree does is just give me authority really. There’s nothing relevant in the degree.’

Interestingly, some participants explained that they had completed a particular degree in the engineering field, not realising that there was a degree that suited them better:

‘I did a civil and construction degree and there was no construction in there whatsoever... now there’s a construction management degree which everyone that I work with does, and had I known about it, that’s the path I would have gone (down).’

‘If someone had told me that engineering was maths in disguise before I applied, I wouldn’t have applied.’

3.1.3 Commencing in the engineering workforce

Getting a job

Many participants referred to the cyclical nature of the engineering industry. In the boom time there is a profusion of jobs in every part of the sector, but when things slow down jobs can become scarce. As a means of trying to avoid the negative impacts of the cycle, one participant said she strategically applied for jobs across various industries, because as some industries were in decline, others were rising.

For many participants, their experience and that observed of others was that by undertaking significant periods of work experience during university, there was a strong likelihood of being absorbed by the company where they had worked. The participants spoke about the ‘graduate network’ and its relevance to starting out in the industry. In the graduate programs, they were able to get some practical experience without feeling that they were thrown in the deep end. However, this depended on the company. Some were thought to have very good graduate programs and others were thought to hire graduates simply because they were cheaper.

When asked whether gender was an issue when applying for work, general consensus was that it was not. Most employers seemed to be very keen to hire female engineering graduates, and many even implied that being a woman was a bonus in applying for jobs. For example, one recent graduate who got a position through graduate recruitment said that:

‘gender plays an issue in getting you noticed, but they say (and I would like to think that in the end when they’re assessing everybody) that they recruit you on merit and not gender.’

Many founds that gaining employment was not an issue when they graduated, experiencing a large demand for engineers and many graduate recruitment programs.

'Yeah, I got three job offers when I graduated.'

'...by just applying to a company and yeah entering, they were really welcoming and they've got all these really great graduate programs and sort of systems in place now and I feel like we're almost nurtured too much.'

The woman who had studied as a mature aged student said she was interviewed by two female engineers for one job, and while she didn't encounter sexism, she felt that she encountered ageism.

The positivity towards women experienced by the participants here is an important finding. However, all the women involved in these conversations were (or had been) employed in the engineering industry, and thus might be considered 'success stories'. A different story might possibly emerge from qualified women engineers out of the current workforce.

3.1.4 Reflections on engineering work

Conditions

All agreed that engineers are well paid in Australia (especially in comparison to the UK and other countries). However, it was understood by some that men in the field earn more than women. One participant explained that there is a culture of companies asking prospective employees what they think they should be earning and that women are less likely to ask for more money than men:

'Well I went into a job interview last year and I asked for something that I thought was my package and I got that as my base. So it's pointed out to me that I was asking for 10% less than I should have been right? So women do tend to ask for less than they should and unless you have someone that you can talk to.'

'I know for a fact, because I've discussed it with my boss, that women in our team get paid less than the men and he's trying through the remunerations... he's trying to right that, but you can't just come straight out when you talk to women... so he's trying...'

'... I definitely know next time I'm going for my next job I'll be coming out and going "Guys, what do you reckon I should be getting?" Like unless you have a network like this, you don't know quite how much to ask and the guys, not only have the network because there's like more of them but they're all probably getting paid more anyway... They definitely are! I'm just remembering a male, not a colleague but a friend, and he's like "Surely I should be getting a 100K three years out, shouldn't I?" I'm like, he's four years out and he's a marketing guy and he asked for it and he got it. There's a little bit... the confidence...'

In terms of professional development, this was dependent on the cycle the sector is currently in and whether their bosses will pay for such activities. Another issue raised in securing professional development opportunities was that if working part-time, the opportunities were scarce which in turn makes it more difficult to keep skills current.

'... if there's a conference and its two days a week and I only work two days a week, its hard to justify that to my employer. ... It's fine if you work for an organisation that just goes "Yep... Tick... Someone upstairs will pay for that." But when you have to pay for it yourself and you're an at home mum, not working full time and you do want

to have a career one day in engineering, like full time again, but probably not for a while. You know, salary wise, it might be better than other professions but it's still not very much to justify a \$1000 course and things like that so I think that's the thing I struggle with the most.'

However, a number of the participants felt they could influence these decisions by maintaining close relationships with the people who make decisions about PD career opportunities.

'I was talking to someone the other day cause I'm looking at moving into roles and she was in a position where kind of third year out her manager went to her "Look, there's this Masters program that our company is willing to fund. You'd be perfect for it" So they put her on the program and gave her a supervisor role and gave her the role she need to put in practice what she was learning with Masters and stuff as well and when you talk to a couple of your managers, like you said, if you build on that relationship and they can see they you actually want to do it, a lot of them are open to helping you push it along.'

Flexibility was seen by some to be a catch phrase put into job advertisements, but something that would only materialise in the workplace if there was a manager who believed in providing flexibility and diversity.

'I think flexibility and all those catchcries are something that they put in the job ads and they put in the section of the website about diversity, whatever, and most of the time, it's exactly who your manager is or exactly who you're reporting to that makes the complete difference.'

One participant noted that this was especially true in defence-related jobs, because a direct manager can say that flexibility is not suited to a particular role and the employee will have to fight for it.

'I've had one of my friends who was pregnant at the time and they were about to say "No you can't go on maternity leave!" It's like "I'm eight months pregnant!" and they're like "You're not allowed any time off..." and because your direct manager can say "No, we don't think flexibility is suited to this role" and then you have to fight for it.'

The participants had a range of different experiences when it came to maternity leave entitlements, with estimates ranging from 2 weeks to 3 months paid leave. But they were able to name companies that they believed had good maternity leave policies.

One participant explained that she took seven months of maternity leave and returned to work slowly increasing her hours spent in the office. She believes that engineering is an excellent profession to be able to work from home. She said this is perhaps partly due to her particular position, but also more generally because it is a very well paid job so it's worthwhile to work part time.

'What's really good that they did for me was I do sixteen hours a week but I can find the time anywhere in the week so I can do... if I'm up at midnight, I can do it or if my bub's having a nap, I can do it then so I don't need to have designated days where I'm sitting in front of a computer and that's been the greatest part of it, to get that flexibility.'

Another participant who is currently pregnant explained that she was worried about sharing the news of her pregnancy:

'...because it was at a time when I was moving between projects and they could have easily made me redundant without it being noticeable. But they've been actually great and they've moved me into the new project and they're still training me and giving me the time off for maternity leave.'

The group agreed that the majority of the industry was accepting of diversity and equality but that there were still elements that were more 'old school'. There was a comment made that the focus has to shift away from maternity leave and to parental leave instead:

'And you got to bear in mind, it's just an equality thing, ... I mean it affects women more cause you tend to have the maternity leave issues but guys want to take time off, guys want to work four days a week. It shouldn't be... it's got to move from this 'women need it cause they babies' to 'parents need it cause they have babies'.'

While there was a discussion about the psyche of engineers and the fact that they are technically oriented people and that this might affect their ability to work in people oriented positions, the consensus seemed to be that things didn't usually turn out that way. For example, the recent graduate in Perth said that she had found the conditions *'way better than I expected'*. There was a contribution to her public transport, flexible working hours and a good working environment.

Workplace culture

The participants explained that there is a divide between technical and managerial roles that as they progress through their careers they find increasingly difficult to breach. They agree that it is very important to have technical knowledge in order to manage successfully. Ultimately, if a project gets off track, it is up to a manager to get it back on track and to do this, they need a working knowledge of that project. There are different skills required for each role, but some participants discussed how difficult it would be to have to retrench a colleague, for example.

In general, the overall experiences were of a positive workplace culture where women were respected and treated as equals. However, there were exceptions to this:

'I would say it's 95% really great, the best fun and there's 5% [who are not so great]. Until this year, I hadn't come across [these people], but they are quite ugly and they are nasty, nasty, nasty, nasty people...sexist, bullying, harassment, racist, homophobic...'

One group member who was working in the steel fabrication industry described that she had met some 'awful' men who did not respect her ability as an engineer.

'... it's surprising that there's a few people that I've run into in my career that have been awful but other than that, guys would rather have a conversation and a laugh and stuff with a young girl or something, you know? So there have only been a few that really stood out in my career that have just been awful. Actually awful.'

Another member said she was able to use this to her advantage, because the senior male engineers in her construction company were much kinder to her than they were to the male graduates. However, this 'advantage' did not appear to be all that satisfying – she still felt that they did not respect her opinion, but just that they were more aggressive to the male graduates and ordered them to 'go figure it out yourself'.

One participant described a difficult situation where she felt unfairly treated by her direct manager. However, she did not believe that this was because she was female, more because she was a minority within the team. The group agreed that there is a culture within engineering where minority groups are discussed in a derogatory manner and seen as ‘easy targets’.

One participant asking another: *‘Is he picking on you because you’re a girl, do you think?’*

Response: *‘No, I’m the easy target! Sort of that’s where it comes to the minority bit. You know, I’m a nice easy target. They’ve kind of got their nice little boy’s club and it’s not because I’m a woman, it’s because I’m the easiest target and I’m sure if you put someone in there who was... you know they openly say really horrible things about every minority group. You know, if you put anybody else from any other minority group, they would equally get picked on and I would probably not be the target so much.’*

So it seems that women are sometimes discriminated against not necessarily due to the specific characteristics associated with being a woman, but rather for the simple fact that they are often a minority in these workplaces.

However, the participants tended to agree that there is still an old fashioned mindset about female engineers that has prevented them from getting certain types of work. One participant recounted a story where she was passed over in favour of a male colleague to visit gas lines in the field because she had children at home. This was despite the fact that her children were 15 and 17 at the time, and the male colleague had two children under two.

There was a sense that people within the sector thought it was not possible to have a career and be a mother as well.

‘People have said to me you can’t be a mum and a parent and have a career as an engineer’.

‘There’s a clear sense that it’s okay to be a dad and to be an engineer but not to be a mum and an engineer’.

This culture played out more aggressively when one engineering company held its annual work Christmas party at a topless bar. One stated that her team attended the party but went to the back of the venue, which was not topless. The male engineers did discuss the evening at work and this made the participant uncomfortable but she didn’t know how to react *‘because, you know, how do you tackle it?’* By and large, the group felt that it was best to remain quiet and gain ‘street cred’ with the other members of their professional team.

One participant described a boss who told her not to go out on site as she was ‘a distraction’. This was somewhat explained away by the participant as a nasty characteristic of a boss who was offensive to anyone not in his ‘little cliquy group’. However, it does highlight that there are still elements of sexualisation of women in this workforce.

One participant who had worked as a coordinator at the University of Western Australia found that she had female first year students telling her they were very apprehensive about work experience. She advised them that there is a problem in the Australian engineering sector:

'I would just say go to Europe, go and work in an engineering company in Europe because the culture there and the environment there is very different to Australian working culture'.

Another theme emanating from the discussions about workplace culture centred on the 'ingrained' notions of what women are good at, or can do. A clear illustration of this was provided by one participant in Brisbane warned by a colleague early on in her career: *'be careful not to be the woman who is relegated to organising the social life of the company, because that is not high value work.'*

Another anecdote along these lines was provided by a participant in Perth, who had recently achieved chartered Engineer status. She received a pay increase and a congratulatory email was sent around her company. At a meeting, the CEO congratulated her on her achievement and then asked her to make tea and coffee for everyone at the meeting because he could not find his PA.

It was pointed out during these discussions that people subconsciously fit others into gender roles, and *'maybe we are naturally better at admin sort of things like taking minutes or noticing things and organising stuff...?'*

3.1.5 Progression and advancement in engineering

Participants highlighted challenges in progression from a number of points of view. One in particular was related to the aforementioned cyclical nature of the industries involved in engineering and the industry-wide lack of foresight in recognising the boom and bust periods and retaining good engineers through those periods. It was argued that this leads to '10 year arcs' where there are fewer engineers with solid experience.

In terms of making their way in the industry and their willingness to stay with one particular company, one participant stated:

'The most important thing in engineering is having a sponsor within your company who will get you ahead'.

A group member explained that her company had conducted an employee survey and had found that the women had lower opinions of their workplace than their male colleagues. This company had begun a mentoring initiative called 'the academy' to address this.

'They did a staff survey. They found that the women had a lot lower views of the company than the men did. Especially things like remuneration, that sort of stuff, in comparison with our male colleagues which I found problems with as well. ... and I fight pretty hard to get what I'm getting paid at the moment or to get the same title as the other guys so...'

Another participant was able to list a number of firms with women's groups and also explained that Engineers Australia has a 'Women in Engineering group'. She said:

'I feel like the people are there if you want to reach out to them'.

3.1.1 The future of engineering

One participant worried that there would be a lack of good technical engineers in Australia in the future because people are more likely to choose to project manage earlier in their career because they believe they'll earn more money that way. Therefore good technical engineers

will be in very short supply. This is already happening in the aerospace industry where once an engineer has been working for five years, the company will be very unlikely to let that engineer go because *'it's rare as hen's teeth to get an engineer with 10 years' proper experience.*' There are some companies who are trying to address this by matching technical and managerial salaries, but participants could only name a few.

Participants agreed that engineers like to do technical work as it matches their personality:

'Give me Microsoft Excel, give me a computer program, make me do something really complex...and that will make me happy. Job satisfaction tends to go down when you just want us to project manage something.'

One group spoke about a current downturn in the civil and mining sector, although this was not seen to affect the entire engineering industry which is booming in some fields. They also mentioned a sustainability issue with rates of pay compared to the rest of the world. So there is a worry that more jobs will be outsourced. One participant discussed the importance of national politics on job security as many policies have recently been aimed at the resources industry:

'Look and that is definitely an aspect that I think politics has a lot to play in what happens too. Especially, since the GFC, and even maybe a bit before that, political decisions, whether they be good or bad, seem to drive especially the resources industry and how they're going to go forward.'

Overall participants in the women's focus groups were positive about the future of engineering because *'lots of initiatives are starting and gaining way more momentum'*. There are support groups and initiatives to balance pay between genders. Now what needs to change is the subconscious issues so that women are not always being asked to make cups of tea.

3.1.2 Examples of best practice approaches

Support for women – during study and in the workforce – was mentioned by the two groups a number of times during the discussions. Some ideas from participants about the best elements of this support are highlighted in the next few quotes.

Many participants had supporting university experiences, explaining that the opportunities for women to get involved and feel connected were there if people wanted to engage with them.

'The (internship) work helped, the subjects that I chose, the mentoring that was available; not just the female mentoring but the general mentoring. The co-curricular activities that I did, the overseas exchange, you know there was a thousand opportunities if you took up a couple...'

Beyond university, participants identified a range of support mechanisms on offer for women.

'I guess there is support there which is great and Women in Engineering, Engineers Australia. I feel like the people are there if you want to reach out to them.'

The idea of targeting the female university students to join women's societies divided the participants. While some enjoyed the networks that these opportunities provided, others did not appreciate being singled out as a minority group.

'... in my last year at uni, they decided we needed to have a women's group because you're a minority and it had to be all women had to do this stuff together once a year. And the three of us who were in the final year together, that were female out of the

whole eighty guys, we got told we had to do it for the younger grades and we're like "Nah..." We ditched it completely, didn't do it. We had our Civil and Mechanical Engineering student societies, which were just drinking sessions, and they support everyone anyway.'

As mentioned earlier, many participants had experienced good flexible working and remuneration conditions, although it depended on the particularly employer and/or manager. Nevertheless, some participants questioned why we cannot change the Australian workplace culture, citing favourably conditions for women elsewhere:

'I keep looking at the Scandinavian model and saying... in Finland and in Norway... they have engineering companies with different conditions where the women are more respected?... If you're working on a project and it's getting towards four o'clock and you have to go and pick up the kids but you're stuck at work, the company provides this concierge service. They will go and pick up the kids for you.'

The flexibility experienced by some women (especially with children) was generally positive. For those who had to leave early to collect children, and so on, they were given the chance to make up time when need be:

'I just keep my own diary, yeah. But it is a bit of a trust system. So I keep my own records; no one's ever asked so I've just got really good managers that I've worked with previously that trust me.'

One recent graduate was impressed with the conditions offered to her:

'Yeah, it's way better than I expected - all the conditions. ... there's companies, when they get bigger, they have so many kind of policies and they really want to... like when I tell my friends that I get \$150 towards my SmartRider. Things like that that I never thought I would get. I feel like it would really depend on the company and the big ones tend to go for like the flexible things and stuff like that so I'm really happy. Yeah, flexible working like start and finish. As long as you do the hours and within a certain... Yeah, they're pretty flexible.'

3.2 Mature-age Engineers

Summary of findings:

- Opportunities for engineering work in Australia have changed in the time these participants have been in the workforce. Government as a major employer of engineers is long past, and with this the demise of cadetships. The era where you could serve one company for your whole career, was an era in which many participants began their engineering careers, but it was widely recognised that this is no longer a common experience.
- The current era is seen by participants as more focused on a highly specialised set of jobs, less rotation of workers to broaden an individual's range of expertise, and less mentoring.
- Participants believed rapidly changing industry is altering demand for engineering skills. For example the manufacturing downturn in Australia means a wide range of skills are no longer needed. Therefore, those with such expertise have to either change industry or follow the manufacturing and go overseas.
- There is a feeling that the growing emphasis on management rather than technical skills in engineering is misguided and detrimental to the future of the workforce and the economy.
- Mathematics is crucially important to engineering, yet there was a strong feeling among participants that it is being left out as a prerequisite for entry to university courses and is not encouraged strongly enough in schools.
- There was recognition that universities have to cover such a wide range – technical, theoretical, soft skills, business acumen, work integrated learning, practical application...and at the same time are (unreasonably) expected to produce 'work ready' graduates.
- The participants in the mature-age focus groups saw the importance of the role of industry in 'educating' young engineers as vital. This industry role needed to be played for current university students as well as new graduates. Focus needed to be in skills above and beyond the theory that is taught at university and this could be facilitated in many ways, including strong mentoring programs.
- These senior engineers see that times are difficult for new graduates and acknowledge the difficult situation new graduates in engineering face in the current engineering workforce. They highlighted the focus of many engineering employers on hiring people with solid work experience and specialisations – the likes of which very few graduates have when they leave university.
- Participants in general believed that the contribution of engineers to the economy is not well recognised by Australians. The consensus was that engineers are undervalued and that creativity and problem solving were not seen as key tasks of engineers – despite these two areas being fundamentally what engineering is all about.

3.2.1 Participants

Focus groups were conducted in Brisbane and in Sydney for mature-age engineers. In total 19 people participated, with the majority (17) in Sydney. Due to the size of the group in Sydney, two focus groups were facilitated simultaneously. The vast majority of participants were male, with only one female taking part in these specific sessions (note that within the women in engineering focus groups, there were participants who were mature-age engineers). All participants were university qualified, several with Masters or PhDs. The majority had

completed their education in Australia, although there were at least five participants who had completed their undergraduate training overseas in countries such as Iran, UK, and Germany.

The experience of these engineers ranged 25 to 50 years in the industry. Participants are currently involved in a range of engineering disciplines and activities, including engineering education, civil engineering (roads, tunnels), mechanical engineering, avionics, mechatronics, energy, and in roles such as consulting, education, contract and quality control. Several participants held positions in professional bodies. There were also some in the group who had recently become unemployed, with at least six currently unemployed or under-employed having been made redundant in the last two years.

In relation to the desired population characteristics (see section 2.1.2), the yield from the mature-age focus groups lacked people working in engineering trades.

3.2.2 Educational pathways to engineering

What attracted you/led you to engineering?

The mature-age engineers involved in the focus groups were keenly able to recall the time, incident or experience which sparked the idea that engineering might be the pathway they should chose. For some engineering was a calling:

'From the earliest recollections I have I wanted to be an engineer.'

'From an early age I had an enthusiasm to do with our world in which we live and our making it work.'

Some cited good role models, particularly fathers or uncles who were engineers:

'When I was young I wanted to be an engineer because my father was working in engineering, differently: he was in the air conditioning business, but I was inclined to do engineering, not mechanical, I wanted to do civil, something like that.'

Others had inspiring teachers:

'I have forgotten many things, but still remember my secondary education- the teachers' names, subjects, where my passion [for engineering] kindled (but I don't remember much about engineering college!) (engineer educated in Middle East)

Some of the focus group participants, particularly several participants from China, were channelled into engineering because of their maths ability, when their personal inclination might have been to follow a different path (e.g. investment banking). However, a number of Australian born participants also felt that their school performance in maths had a strong influence on their choice.

'I was good at maths so engineering was the natural next step.'

'I went to a technical high school; I don't think they have things quite like that anymore. And it was always going to be maths and science and engineering. So, for me, it was pretty clear cut.'

Only a few had considered alternatives. One had done two years of medicine but said, *'I couldn't find myself there.'* One considered architecture, but then went into Civil Engineering. Several said they simply accepted that they would do engineering and didn't

look at other options, and in one focus group the majority reported that they had simply not been aware of a range of career choices (*'If I was deciding now I might be an investment banker'*).

Choosing an Engineering pathway

Several Sydney participants drew attention to the fact that, in the past, NSW government agencies had been major, and attractive, employers of new graduates, offering cadetships, secure employment and on-going training. This had influenced their course choice.

'I studied civil engineering, which is different to mechanical and electrical completely, because when ...I started it was all 70 percent government, semi government, i.e. electricity commission, water boards. Everything was government run. And one of the big advantages of those things was they had centres of expertise; they had in house design, in house construction, i.e. the Sydney Water Board who built Warragamba dam etc.'

This discussion led to some reflections on how different things are today, with many of the organisations and government agencies having been privatised for some decades. One participant noted that while the works were still being done, most of these functions were now *'private partnerships'* and that many of the planning and consultancy-type tasks involved were no longer performed in Australia, rather in the overseas branches of the large private companies undertaking much of this work:

'Exxon Mobil or if you look at Chevrons of this world they've done these fabrications abroad, even the designs are abroad, so all the consultancy industry is very small here now'.

Educational pathways - What about now?

One participant commented that *"Students make choices in year 9/10 (especially about maths) that lock them out later or confuse pathways.'* However, others felt that decisions about which subjects to study no longer had much impact on entry into engineering due to the lack of pre-requisites:

'It's the score that counts, not really what you've done [i.e. 'harder' courses that will prepare you for engineering] because they can all do bridging courses later.'

Many participants had issues with current entry requirements – or the lack thereof.

'Sadly, these days, the hurdle's not as high as we'd like to see it.'

'Because maths isn't a compulsory subject anymore, unfortunately there are fewer and fewer people that are good at maths and science.'

In comparing their educational pathways and decision making processes with those of current secondary school students, participants in one focus group pointed to the fact that, *'it was a different time'*. They suggested that getting a degree was not seen as important in the way that it is now, and that in their day many more people chose to do an apprenticeship. A number of the Australian educated participants had entered university when there were still fees, but no HECS, a situation that they felt had kept many others from choosing this pathway, and made it more challenging for many who did.:

'My parents struggled to help my brother and I go to University.'

'I took 7 years to complete my degree. I worked (in the engineering field) throughout but that was actually good. It meant I already knew the industry when I graduated and I was always applying the theory I was learning.'

In another focus group, there was concern about career prospects, particularly in Australia, and a general feeling that this was (rightly) discouraging young people from choosing engineering:

'You might spend, if you're a young person, four years or more at Uni, spend all your own time and money and build up a HECS debt and lo and behold: nothing.'

'So why have an education to supply people to ...if there's no industry, unless you're going over to work in Tokyo or Shanghai or India somewhere?'

'I have told my sixteen year-old grandson [who wants to do engineering] that he'd better prepare for a career overseas.'

Experiences of Engineering education

In one focus group, participants' attitudes to their undergraduate Engineering education differed markedly, depending on whether they went to an Australian university or a university overseas.

The Australian born participants were highly critical of their engineering undergraduate education.

'When I did my course half the people who started didn't come back after first year. They couldn't cope.'

'First year was a filter.'

'Not just first year. We had a drop out rate of about 50% over the course.'

'I hated my course. It was overly technical. I struggled to get through it. Later I did a Masters. It was much less technical and I sailed through and enjoyed it.'

'The only good things I did were electives outside the faculty.'

'I hated it! Just one example: I was in a course where the lecturer only turned up for one lecture... he announced the exam would be based on a particular text. I went to see him when I found out it wasn't easily available and there was only one in library, and he told me it was my problem!'

However, those educated in the Middle East or China had a very different view:

'In my education, I had the experience of passion (mine) and encouragement (from the university).'

'Education was inspirational. I'm not sure if it was time or geography, but I also think engineering was more defined- we knew what we needed to know.'

'We focused on theory not 'paraphernalia'.'

There were similar differences in regard to the usefulness of what they had learned. For example, the Australian educated engineers agreed with one of their number when he said, *‘How many people use what they learned then? I mean like Thermo 1 and 2?’*

But those educated overseas supported a colleague who replied, *‘Although some may say, “I haven’t ever used that formula they taught me in 16 years”, nothing I learned is irrelevant – all the bits are relevant to who I am now.’*

It is interesting to note that all members of this focus group later criticised current University programs for their apparent lack of attention to the fundamentals of engineering- concepts, principles, theory. At this point in the discussion, the Australian-educated acknowledged that, even though they did not enjoy it at the time, their education had given them a solid foundation for what they then learned on the job.

The participants also recognised that their experience reflected the approach adopted by their university, rather than engineering education per se. Some Australian universities had had a more practical focus, even ‘back then’, and this was still evident.

‘Uni NSW is still more theoretical, UTS more practical — that’s OK. They shouldn’t all be the same.’

An overseas-educated participant in one focus group observed that, *‘the industries available in your country influence what is taught and how things are taught,’* and also the stream you chose to enter. In contrast, another group suggested, that, unlike many overseas universities, Australian universities did not necessarily prepare graduates for some of Australia’s major industries, e.g. gas.

Engineering education - Have things changed?

There was a suggestion in one group that the move away from pre-requisites had created new problems.

‘You don’t need pre-requisites anymore, but those who enter engineering without a strong maths/physics base are taking longer to complete.’

However, a participant who had been involved in engineering education pointed out that:

‘...without pre-requisites, a lot of students do now find it very hard. However government pressure to reduce failure rates has led to the introduction of much better remedial support, and so many places don’t have the drop out/failure rates of the past.’

Other participants felt that pre-requisites were not the only things that had changed:

‘We had a clear vision of what an engineer was. Now there is a blurring of the basics — too much paraphernalia. They have to learn other things in limited hours — tools, processes.’

‘The focus is shifting to process orientation — this needs to be controlled if not curtailed.’

‘Now it is blurred — soft and hard skills, technical and people skills.’

One group suggested that the change in emphasis had occurred in an attempt to meet the changing needs of industry:

'The industry has changed — the large government departments that used to employ many engineers are not doing so anymore. There's more and more focus on private companies who need to keep clients happy, sell ideas, combine solutions, make money.'

'The curriculum has changed to respond to industry need. For example, Civil Engineering is much more broadly based, but it's lost a lot of technical content.'

One participant drew attention to the 'remarkable changes' that Engineering education has been through since a review in 1995, which suggested that courses were too constrained and too focused on technology, and led to the introduction of business skills and 'soft' skills. More recently, he argued that the increased focus on outputs had led to engineering courses that were designed to produce competencies, 'rather than focusing on what might interest and excite the lecturer. This was a very significant change. There's been a lot of thought put into this and it has had a fantastic impact.'

Most participants supported the increase in work integrated learning. For example:

'You mentioned "work integrated learning". Well, a lot of the universities are starting to look at that and certainly among the young clients that I have, it's way easier if they've got some relevant work experience and haven't just worked behind a bar or a coffee shop and actually come out, because they come out like peas in a pod, so which one do I choose, you know for my graduate program or whatever. So the differentiator is having that real world experience and actually saying "He's actually done something, he actually knows a bit about the about the practicalities as well".'

Many had created their own versions of this, having worked in the industry throughout their university courses. While some took several years longer to complete, they felt the combination gave them a far better grounding than they might otherwise have had.

However, many participants in one group repeatedly returned to the need for university courses to reconsider their emphasis. One group attributed many of the reported problems with the performance of young engineers to a shift away from fundamentals within university courses.

'Courses do focus on technical competency, but graduates don't know how to define and scope a problem where there is insufficient data...

(Interjection from another participant, 'You mean real engineering in real life')

'... yes, where you have to make assumptions that suit the stage of development of the process. Unis CAN'T teach this, but they MUST teach fundamental theories. Giving students this fundamental grounding is critical.'

'It's really important to teach principles — new graduates can enter data but they can't make sense of what comes out, or test outputs of software from first principles.'

'Today they are data collectors, not engineers. They need to learn how to apply engineering to the data.'

'In teaching, you need to keep the emphasis on 'the main thing' [i.e. key principles, concepts, fundamentals of engineering]'

'Unis should be teaching habits of thought, problem solving, how to search for and recognise the right information.'

3.2.3 Commencing in the engineering workforce

Participants had had mixed experiences when it came to finding their first jobs. Some selected a stream (e.g. Civil Engineering) on the basis of the jobs that were likely to be available, and entered the workforce without apparent difficulty. Others did not find it so easy to go into the field they had envisaged. For example:

'When I studied civil engineering I thought I was going to be a structural engineer or something like that. And when I graduated: no structural engineering jobs anyway. It was for the elite people in that had HD's and that were good at computers and that sort of thing. So I ended up in project engineering.'

Overseas trained engineers reported few problems at the beginning of their Australian careers.

'I came to Australia in 1990, my company brought me here because they had a shortage of engineers, and I ended up working for them for 25 years.'

'When I came to Australia, I found I couldn't get into the workforce unless I did a Masters. When I was doing this Masters, a lecturer advised me to learn how to use particular software. It was good advice, very useful. It got me a permanent job and security for many years.'

However, the majority of the overseas educated engineers attending the focus groups had been made redundant in the last 4 years, and were now unemployed or underemployed.

Participants in one group focused on the lack of jobs for new graduates now:

'The universities are really struggling, they really can't find placements for people and that is very serious. So what's a young person going to do when he goes through his university course? Say, "Well, I'm qualified but I don't know what I have to do if I go into the industry?"'

'Some of the firms do have graduate programs, the bigger ones, but I don't know, I can't imagine the intake's very large at the moment, because they don't need many people. And also, they take the very top of the tree. And [not] the basic engineer, like we all were once...I wasn't particularly specialised or anything. I just wanted to work.'

One overseas trained participant commented that the mind sets and priorities of new graduates had changed.

'I had a dream. I was happy to have my first job. I would have done it for nothing! Now they only seem to care about the money. There is no passion.'

When asked about their perceptions of new graduates today, for example were they 'work ready', one participant exclaimed:

'Work ready? They shouldn't be! The concern is flagged all the time that Unis should produce 'job ready' graduates, but efforts in this direction rob them of the theory and knowledge they need. Unis can't teach it all.'

The consensus on the basis of the comment above was that there was a strong role for industry to teach young engineers (preferably while still studying) the specifics needed for the ‘work readiness’ attributes employers are seeking. While this tends to happen to a certain extent through placements while at university, there was a feeling that more should be done:

‘It’s essential that engineers at all levels and stages are exposed to industry practice.’

‘In Australia, a graduate one year out of uni can be running a project. It doesn’t work!’

‘In Germany, you can’t be an engineer until you have completed a Masters degree and worked a year in industry. Then you get a little responsibility, then a little more. As you do more study, you get more responsibility...’

Characteristics of a good engineer

One group was asked, ‘How do you know you are working with a good engineer in your field?’ Participants were in agreement that good engineers:

- *know what they don’t know*
- *are able to find answers through research or asking others*
- *ask the right questions to define problems*
- *solve problems elegantly and cost effectively*
- *always focus on cost effectiveness, (not necessarily cheapest)*
- *work well with others; and*
- *design the new, and innovative.*

In discussing how an engineer developed these skills, participants cited learning on the job, over time, and highlighted the importance of a variety of approaches that had helped them to learn, such as cadetships, job rotation and formal and informal mentoring. However, there was general consensus that times had changed - and not for the better:

‘We used to place young engineers with clerk of works to teach them the nitty gritty of the site...They didn’t teach that at uni.’

‘In the construction industry, we used to have people, like carpenters, who showed potential. They were tapped on the shoulder, trained as Clerks of Works, given increasing responsibility and eventually they ran building sites. Now, someone one year out of uni is put in charge, and of course they make mistakes- big ones.’

‘The early mentoring I got helped me to be less arrogant. I am convinced of that.’

‘Unfortunately with what I call the disintegration of the electricity industry over the last twenty years, rotation is no longer a practice. We used to have a small number of large government owned corporations and rotation as an implicit part along with mentoring and networking. The three main things, [for learning] mentoring, networking and rotation - job rotation in those first five years.’

‘In those days they had engineering rotation programs by the companies as well as governments. They’d send you round all the different departments and you got a broad brush before you could maybe specialise in something. And they had a view to developing you as a person for longer term. Not short-termism.’

'Now graduates are expected to be 100% productive on Day One, but they don't necessarily get the support they need.'

All groups focused on the critical importance of hands on practical experience:

'There's so many of the young people coming up, and they look around at pay scales and within three or four years they're saying, "I want to be a project manager." Now in the heavy engineering field that I was in, no-one could get anywhere near that until they'd done about ten years at least, because the whole idea was that when you managed a project you would know enough about a project, you could argue for the project and keep the lawyers out of it.'

Several pointed to different areas of the industry where they felt universities were not preparing graduates appropriately, and where skills and knowledge were in danger of being lost.

[A] problem with graduates is that they come out and they don't know one end of a panel from the other. That's another problem. I spent time on the drawing board; I spent time in the workshop, all sorts of things, so I don't have a problem now, but all the chaps that I've taken on, or interviewed, a lot of them haven't got a clue. I've got one bloke; all he can do is use final element analysis. And that's all very nice, but he doesn't even know what he's bloody well designing. It's stuff like that.'

Another identified gaps in undergraduate programs on instrumentation and control engineering.

'When we look at undergrad programs the two streams that come up to us are electrical and mechatronics. But none of these streams had any curriculum around sensors or instrumentation areas... If you look at the process industry they need control and instrumentation engineers.'

He reported that the graduates he had trained for 3 or 4 years usually left, often to go abroad.

In some fields, young engineers who wanted to develop particular skills now had little choice but to go overseas.

'There's several ways of picking up knowledge, one is you study for it, then the other is you work with it and then you specialise in a specific application. Well, manufacturing is largely gone, obviously in heavy engineering. There is no one left in Australia that makes the things that we used to make that run on it.'

Similar issues were raised about the energy field, mechatronics, construction design...Several participants felt that the Australian Government needed to be much more pro-active in supporting the development of local industries, particularly in manufacturing, gas and nuclear energy.

3.2.4 Reflections on engineering work

There was a general consensus that engineers were not paid enough, and that this influenced young people's decisions about engineering as a career. (However, there were also comments elsewhere that a lot of design work had gone off-shore because it could be done more cheaply.)

A related issue, and perhaps of more concern to participants, was the feeling that engineers were not held in high esteem. Some attributed this to a widespread lack of understanding of what engineers actually do, which was exacerbated by what they saw as the abuse of the term, ‘engineer.’

‘Anyone can call themselves an engineer. People who used to be known as ‘fitters and turners’ ...are called engineers - so they can make their job sound sexy, but it just makes the public more confused.’

If non- engineers were involved in hiring decisions, the lack of appreciation of what engineering involved had implications for engineers looking for a job. For example, one participant told of how he discovered, too late, that a human resources staff member had rejected a highly trained engineer on the basis of his CV because, ‘*he worked in an ice-cream factory!*’

Concern about the lack of understanding of what engineers are, and what they do, permeated much of the discussion. For example:

‘To me it’s all about finding solutions, and the key thing, a concern that I have about the perception of engineering [in the] community [is that] it is essentially a creative pursuit. Design is a creative activity. I think that it’s unfortunate that Engineering is perceived by many, including many in the profession ...as clinical and analytical. It doesn’t need to be that way. It can be, and is to many, a creative pursuit. Solving problems and making a difference in the world.’

Workplace culture

There was not a lot of direct discussion of this topic, but one participant did comment that:

‘A company that I worked in had a culture of name, blame and shame. And that as an overriding culture was just poisonous... Engineering is fundamentally positive and optimistic. Like, you know, “we can do this all the way through to the creativity element”. Unfortunately that positive “we can do this” thing is not powerful enough to rise above those individual company cultural nuances.’

However, comments by others throughout the sessions pointed to areas in which they perceived changes in the culture and underpinning values and expectations of the industry as a whole. For example:

‘Many companies are not willing to take on a graduate and invest time in them – We need a higher level policy to drive this, especially now big govt departments that used to employ and train a lot of graduate engineers are moving to being contract managers only.’

One participant drew attention to changes in work expectations, which, he felt, were undermining young engineers’ opportunities to grow:

‘People shouldn’t be so pressured at work! They need time to dream, research, and learn, but now they are working 7am to 6pm under high pressure. This is not just an engineering issue. It is true in all industries.’

Is experience respected and valued?

The critical importance of experience in the making of a ‘good’ engineer was a recurring theme.

While one group felt that their own experience was respected and valued by others in the industry, they also agree with one participant who said, '*respected and valued but under-utilised.*' In other groups, however, comments suggested that their experience was not valued, respected or well utilised.

A participant told the story of how a young engineer he was mentoring had no idea of what was involved in maintaining the pressure vessels on his engineering project, legally or from a technical perspective. When the topic was raised,

'...his eyes glazed over. He had no idea... So [I said] maybe I need to go and talk to your boss. So the 22 year old Engineer and I, being 50-odd, walk into the office of the 25 year old "senior engineer". He had no clue about pressure vessel certification. ... And it could be killing people...'

Not only was he concerned about these gaps in basic knowledge. He was worried that his attempts to share what he knew were not appreciated:

'I am appalled at, uh, I really want to express this positively but this is going to sound negative — at the lack of value that is attributed to experience.'

Like this participant, others in the focus groups had an obvious passion for their field and wanted to share their knowledge with others. However, while some already contributed to formal mentoring programs, others were surprised to find that they existed.

A number talked about the importance of mentoring on the job, and the implications for industry of not valuing and retaining their most experienced engineers. One participant commented, '*I used to mentor three graduates at a time, to teach them what I knew every day but then I was made redundant and they are still there. It is dangerous for engineering to follow these practices.*' When asked if he thought it would have been better if he had not shared his knowledge, he emphasised that it was important that he did, but he was more concerned that the organisation was prepared to lose his knowledge before the young engineers had developed enough of their own.

Technical or management focus?

There were a range of views on whether a mature-age engineer should continue to focus on technical aspects or move into management.

'If we're talking about ceilings or glass ceilings or whatever, and how far engineers can go and what sort of further education they should have, you've really got to ask yourself the question, "Do I stay as a super technician and do more engineering and do a PhD or a Masters and become a specialist, or do I want to get into general management and become the head of a company?"'

'In terms of career progression, are we really saying that engineers want to stay in their narrow little band and just become better engineers or more senior engineers and what is the ceiling? Because you're not going to become a multi-millionaire unless you become the top of a big company or invent Apple computers or something.'

'Most engineers don't want to be managers, it's a career thing. You're not going to look at company manager or director, unless it's your own firm for at least ten years and by that time, you've decided what you want to do. I mean, I'm a manager, but I didn't want to be, it wasn't part of my career plan. It just happened that the bloke I was working for left and they didn't have anyone else and they put me in there, and I'm still there four

years later. But [at] the Ford motor company I worked in manufacturing, product design, testing. I had a very exciting job and I didn't want to become a manager... Does that make me some sort of pleb? I don't know?'

One participant found that having technical and management skills had given him the ability to adapt to a changing environment, but that it was the technical skills that had proved to be the most valuable:

'I think all of us here; most of us anyway, probably started out in that era when it was possible to stay with one company all your life and have reasonable prospects of development within it. Then probably, I would think around the eighties, it started to creep in about, well, you don't do that, you find alternative ways around to the top.'

'But the thing that's wrong with it is that you can end up with management skills, leaving your technical skills, and if you lose your position as a senior manager, you're going to find it very difficult to go back into the workforce. In my case, I worked past normal retirement age but after the [company name redacted] debacle occurred basically they walked away from it, I fell back on my technology and for the last fifteen years, it's served very well. Served me very well ...'

Based on his experience, this participant offered what his advice for new engineers today

'If you want to be able to earn for as long as you wish to, stay close to your technology, because that's what will be special, not the management skills, they're not special.'

3.2.5 Progression and advancement in engineering

The tension between mature-age engineers focusing on technical rather than management skills could impact on progression, advancement and salaries. One participant argued that many companies placed greater value on management skills than on technical skills:

'So if you look at the company progression or what they call 'career development cycles', you will have most of the people's pays and things linked with how many people they manage and if there are any profits sent up, while the engineers, if you're really passionate about doing your engineering, you're not in that circle. Your salary progression does not progress in the same way, so all that carries you is your passion for the job. So I think there has to be some structured value system in the company as well, say, whether the technical stream has the same career progression as the management has. That's what changes the perception in the long term.'

One participant described working for a company with a different arrangement:

'The company that we held a licence with, ...had a parallel stream of development like a lot of German companies, and you could either go up the corporate ladder or up the technical ladder and [on] the technical ladder, the senior titles were consultant and senior consultant and so forth..And these guys were good; I mean these were the top of the industry.'

A participant drew attention to the important role played by professional bodies, such as Engineers Australia and the Instrument Society of America, which do a lot of work in certification of engineers to give them status in areas a company can place a value on. However although Engineers Australia had done a lot of work with Continuous Professional Development (CPD), he felt that this needed to go further. *'I think CPD is still very generic*

competences. I think we need to have ...technical competency structures which are beyond university levels.'

While there was limited discussion of participants' own approaches to career planning and progression, there was an interesting comment on how a participant viewed the plans of others:

'There was a guy I interviewed a couple of years ago, I mean he was only about 26 or 27 maybe a little bit older. He had a plan; it was very slick, you know, he looked more like lawyer or a banker. And he had a plan, right? Now, I didn't want somebody who was looking for his next step through the hierarchy, I just wanted a bloke who could do the job that I wanted, and was versatile.'

Another participant observed that many young engineers were highly adaptable, and prepared to shift fields in order to find work, but that this undermined a company's investment in their training and ultimately reduced the skill pool in that field:

'Universities are doing a good job, the graduates we do get, they are not dummies. They are very good graduates. They know it. But by the time that they get productive, it's like 3-4-5 years and by that time, there is not enough industry to take that experience somewhere else either...So, what happens is that 2-3 years they stay with one company, they will change around because there's not enough jobs for that particular field. They will actually switch their careers. And we've seen that time and time again. We train them in a certain way and then, four years later there is not enough industry to give them that career path and they will switch.'

Few participants felt that they had been discriminated against on the basis of their age, as such. Those who had been made redundant saw it more as evidence of a lack of understanding of the value engineers could add and a focus by non-engineers on short term economics. One said that he did not feel that engineers were respected, whatever their age, and were, *'always criticized by non-engineers'*. He had worked in a government department where, he claimed:

'...engineers were seen as trouble makers...They would say, "You stop us from doing things!" And I had to say, "Not me - it's Newton and the laws of motion that say you can't!" They [decision makers] had no understanding of what is involved.'

Age and life stage did however impact on the mobility of some participants. Several who were out of work felt they might be hired if they moved elsewhere in Australia or overseas, but they did not want to relocate away from their children and young grandchildren.

It was interesting to note that those looking for work, particularly those who had been educated overseas, wanted assistance to maintain their technical knowledge and to find work. They were however, generally unaware of professional development programs, career counselling or mentoring services already available through organisations such as Engineers Australia.

3.2.6 The future of engineering

Current trends leading to future challenges

Across the groups, there was considerable concern about the future of Australian industries that might employ future engineers or that might provide opportunities for specialised training and experience:

'Which branch of engineering? Is it civil, or is it electrical, electronic or whatever, and who's got a crystal ball? Because all of these engineering industries are dying. Obviously there is work in the communications industry, you know, there's the NBN which is spinning work like there's no tomorrow.'

'So there are certain things that we'll still need, and anything to do with communications, computer technology, those sorts of communications are still thriving, but we need to know as a country, what are the core skills and innovation and all the other things which will actually take us forward into the future? Given that we still have a small population, we're not going to be able to exploit too many things and commercialise them because we don't have a critical mass, but we need to use those niche skills, and it has to be in areas where it can't be overtaken by foreign resources that can do the easy stuff, so where does that leave us? You know, that's the big question. What should we be aiming for? What are we going to educate? Because what jobs are actually going to be out there for graduates when they graduate?'

Globalization was identified as an issue now, as well as a challenge for the future of engineers in Australia. For example, several participants were concerned about the future of design skills in Australia. Would all the design work move off shore, with Australians only building and operating?

'Lately what we've seen is that most of the consulting has shifted abroad because of the globalisation of the engineering force and if you look at the ... project being put in Darwin, the design is happening in Singapore, so what we're left with, when the plan comes in here, we just construct and operate it. So ...the brains behind and the consultancy where most of the skills are to be learned, that's gone away.'

Participants felt that vital skills were being lost:

'I've gone back in, having gone in through design engineering management. Right now I'm doing consulting work and I'm right back in design. And the reason is there's no-one else out there when they've got a problem. Even the consultants won't touch it.'

'The maintenance of these facilities is falling off because these people don't understand the basis of the design, or even the codes that were used or are required.'

'I do a lot of functional safety courses and this is a very new science which has come into the industry now, and people are being certified, but there are not enough organisations taking a step to certify and propagate that field.'

They also felt that opportunities to develop industries built on Australian resources were being missed, particularly in the energy field:

'You would think that with of the smart people, the oratory facilities and so forth in the universities; they could stream them into something that would give us more industries. Nuclear is one. And one that is close to me, I started out making water heaters for [company name redacted], I was a [company name redacted] cadet, and I thought, "I want to get something really heavy in this" and I went to Canada and worked in the nuclear business and came back to Australia when we were going to [set up nuclear plants].'

One group was asked: “If you could make one change that would address a critical issue affecting the profession and/or help attract and retain people in the industry, what would it be?” They suggested the following:

- *Ensure that ‘engineers’ have a professional standing*
- *increase pay rates to attract young people*
- *Need to have somewhere for engineers to work — Government must strive to get manufacturing to stay here! This would mean R&D, real engineering jobs and would increase value of and respect for engineers*
- *Legally reserve the term ‘engineer’ for people with qualifications*
- *Get politicians on side, supporting engineers in the issues highlighted in the points above.*

Ideas for Engineering education

Several participants focused on the need for a multidisciplinary approach.

‘I’m involved with the Warren Centre at Sydney University and they keep trying to say, “Why can’t you get the business schools and the engineering schools together?” The engineering schools do come up with some good ideas, and the business schools usually are looking for topics for post grads to do business plans for. Fine, but why not get them together? The Americans seem to do this pretty well, and the Germans have done it in the past, but that’s a matter of whether or not we can stimulate the need for high value engineering in Australia, rather than leading people into it, but I would suggest that if that kind of thing was going on, you wouldn’t have a problem with people wanting to get into it’.

‘There’s the business case and the economics case and everything tied in with engineering. Because engineering is a sound technical discipline and to tie it in with business, naturally, to tie it in with almost all except lawyers and doctors and even bio-medical is a tiny little field, but all the bio-mechanics and everything has to be handled reasonably by engineers.’

Well we should have an MPDS, you know? A Monitored Professional Development scheme and maybe it needs to be paid for by government or as part of the university fee thing, the graduate pays it as part of his fees and the university gives it down to the employer, you know.

Another participant suggested giving new entrants a year of training in the tools and services specifically for that particular business, and offering workshops, with accreditation, every four years.

3.2.7 Examples of best practice approaches

During the discussions covered above some key approaches were apparent that highlight some best practice and considerations for the future. Key approaches fit particularly within the themes of:

- Work Integrated Learning;
- Mentoring;
- Cross disciplinary approaches; and
- Increasing the recognition of the value of the engineering profession.

Some insights into best practice in each of these four areas are illustrated below through quotes from focus group participants.

Work Integrated Learning

This area is currently covered through the work placement requirements for all students in engineering. However, practice in this area is seen as inconsistent. One participant highlighted an approach that not only worked for developing the skills of engineering students, but flowed through to fostering the capabilities of graduates as well:

I was involved in a graduate program in one company and in the 90's we used to take every year about 5 or 6 graduates on site... We used to have a student experience program which ran from October till February, when they had their holidays. So within that period we'd be able to assess the students to say whether we could take them or not, but they still went through a proper interview and once they were selected they had a two year rotation program on the plant. And that's what we did. We used to take about 4 or 5 graduates every year and the student intake used to be about 12 or 13... It used to take a lot of effort on the person who was mentoring because ...for example I didn't want to give them coffee to make, I wanted to give them certain projects to do.'

Mentoring

While the experiences of the mature-age engineers involved in the focus groups suggests that many themselves act or have acted as mentors, interestingly one of the 'best practice' examples of mentor programs that not only involved developing a relationship with a senior employee, but also assisted young workers in gaining greater experience were those operated through the previously government-owned 'board of works'-type employers. One participant described the facilitation of mentoring and skill widening as follows:

We used to have a small number of large government owned corporations and rotation as an implicit part along with mentoring and networking. The three main things, [for learning] mentoring, networking and rotation - job rotation in those first five years.'

Cross disciplinary approaches

The link between engineering, business, law, politics and a range of other areas is apparent through the discussions with mature-aged engineers. A couple of participants highlighted particular efforts by the Warren Centre at the University of Sydney:

'...They keep trying to say "Why can't you get the business schools and the engineering schools together?" The engineering schools do come up with some good ideas, and the business schools usually are looking for topics for post grads to do business plans for. Fine, but why not get them together?'

'You have got the Warren centre thinking about anyway. There's the business case and the economics case and everything tied in with engineering. Because engineering is a sound technical discipline and to tie it in with business, naturally.'

'The Americans seem to do this pretty well and the Germans have done it in the past, but that's a matter of whether or not we can stimulate the need for high value engineering in Australia, rather than leading people into it, but I would suggest that if that kind of thing was going on, you wouldn't have a problem with people wanting to get into it.'

Increasing recognition of importance of engineering

Participants pointed to examples abroad (generally in Germany) where the engineering profession was held in high esteem and saw the practices employed in creating this esteem as worthwhile considering for Australia:

'In Germany, you can't be an engineer until you have completed a Masters degree and worked a year in industry. Then you get a little responsibility, then a little more. As you do more study, you get more responsibility...'

'The company that we held a licence with,had a parallel stream of development like a lot of German companies, and you could either go up the corporate ladder or up the technical ladder and [on] the technical ladder, the senior titles were consultant and senior consultant and so forth..And these guys were good; I mean these were the top of the industry.'

3.3 Recent Engineering Graduates

Summary of findings:

- According to graduates involved, the decision to pursue engineering was generally related to interest in and aptitude for mathematics – and recognition of the links between mathematics and engineering occupations.
- For many of the participants, their understanding of and interest in the engineering workforce was developed through following the experiences of family members who were engineers.
- For others, interest in engineering was sparked through participation in hands-on activities initiated by university engineering departments and aimed at middle-to-senior school students.
- The transition from school into university is critical, and the experiences of participants were quite variable – some feeling out of their depth in the early years of study, while others felt there was not enough challenge.
- In general, graduates believed their courses were overly theoretical and could have been more practical.
- However, there was some difference in the theory/practice balance experienced by graduates at university, with those from the more research-focused institutions experiencing a heavily theoretical oriented course, while those from more technical-based institutions having a more in-course practical experiences.
- Without doubt, the self-organised work placements (or vacation work) undertaken by the graduates during their university studies was considered seminal in workforce preparation and in providing an entrance to employment on graduation.
- However, graduates highlighted the difficulties and complexities in gaining placements. While those involved in the focus groups were the ‘success stories’, these graduates described the arduous task of applying for placements – with a rigorous processes similar to applying for their first jobs as graduates.
- Experiences in gaining work as a graduate engineer was relatively positive for this successful group of graduates, although approaches taken did differ. Some gained work following ‘blanket’ application to dozens of employers, others gained their first job directly through placements they had undertaken during university study.
- For those following the ‘graduate position’ path into the workforce, there was a feeling that in the big engineering companies, the application process was a bit of a ‘black box’, and new graduates found themselves competing for work with engineers with more experience.
- In general, graduates tended to think that their employers were supportive of them as new engineers and that workplace expectations were realistic. Most of those involved could see clear pathways in the future with their employer – although there was a clear example of more precarious employment for one participant.
- Graduates were generally positive about the culture of their workplaces, although there was some cynicism about the prevalence of ‘politics’ within the workplace and the extent to which this might impact on prospects for career advancement.

3.3.1 Participants

Engineering graduates were invited to attend focus groups in Melbourne and Perth. In total, six graduates attended the sessions, three at each. The graduates involved spanned a range of

disciplines, including chemical, civil, electrical, petroleum. All graduates had at least completed a bachelor-level degree and one also had a Masters degree in engineering project management. A couple of the graduates had undertaken double-degrees, with commerce being the other degree in both cases. In total the graduates participating had come from five different universities. These universities spanned membership in the Group of Eight and the Australian Technology Network (ATN) groupings of universities. There was even representation of male and female graduates across the two sessions.

The participants were all working or studying (five working, one studying) in the field in which they had graduated. In terms of employment, there was a mixture of very large multi-national engineering firms and small to medium enterprises (SMEs). Of the five participants employed, three were employed in specific graduate positions as part of a formal graduate program, one was a graduate but in a less formal program, and one was working as a contractor.

The participating population for the graduate sessions lacked graduates from the VET areas, despite these graduates being part of the desired population for this project (section 2.1.4 details the desired population and section 2.4.4 outlines the recruitment processes for this group).

3.3.2 Educational pathways to engineering

Choosing engineering

In general, the participants were drawn into the fields of engineering due to their interest in and aptitude for mathematics and science subjects. However, linking these skills with actual engineering disciplines is not necessarily obvious in the early years of secondary school. Participating graduates generally had made their decision to study engineering during the final three years of high school with work experience opportunities a key motivating factor in decision making, for example:

'I suppose my kind of epiphany was after Year 10 work experience, when I did work experience at an architectural firm. I hated it and realised that I liked the maths parts of structures and everything more than design and the attention to detail about door trimmings and stuff like that...I mean, engineers solve problems. What more is there to say really?'

Similar to work experience, another key ingredient in sparking an interest in engineering came through camps or other activities promoted by universities in the schools these graduates attended. One participant said she had had no idea what engineering was until she went to a camp run by a local university during the holidays.

'I went to an engineering camp in year 10 run by UWA and you do like three or four days and you stay at one of the colleges and learn a bit about engineering and different types and they had different activities based both on campus and in the city like at different firms. Like we went to Woodside I think I remember and they did fun activities such as making gyroscopes and we got to look at the robotics department and see the projects they were working on and that sort of thing.'

Some others who participated in such activities found that while they had already considered engineering, these camps or day sessions helped them to identify what area of engineering they wanted to pursue.

'RMIT ran a Women in Engineering program in Year 10 and I was selected through my school to take part in that so we came here and it had an aerospace field so it was focused on the aerospace industry. They took us down to Fisherman's Bend, the HQ there. We did a couple of activities and I knew I didn't want to go into aerospace but I knew engineering was where I wanted to go.'

Family were also extremely important in the 'education' process about the engineering workforce, pathways and options. A number of participants had strong connections with engineering through their families.

'I have a lot of people in my family that are engineers, and I guess I knew pretty early on in my life that I was going to be an engineer just because I enjoyed the things that they talk about and I used to love building things just out of anything. My Grandpa was a civil engineer. My Uncle is a mining engineer and my Auntie is a civil engineer as well. So yeah I guess it was just, not a given but that's what I was good at as well.'

'My uncle is a mining engineer and has been for the last 20 probably 30 odd years... I had a chat to him about what he did as a mining engineer and that seemed quite interesting and I also saw that given that the state that we are in resources and mining engineering was probably a reasonable career path to go with which is probably why I picked that. I eventually changed into petroleum engineering after a year of mining at Uni, but yeah I would say he was pretty influential in me deciding on engineering.'

Exploring issues of different choices for different genders (and the tendency for engineering to be male dominated), the general consensus from participants was that the choices to follow this pathway were based more on the individual's aptitude for the maths and science subjects rather than based on whether men or women dominated the fields. One female participant emphasised this:

'I think it's more to do with what type of subjects you like. I would say that there's nothing stopping you from becoming a female engineer just because there're less of us... So I think you need to have that aptitude and that love of technical things first before you can ever hope to go down this path.'

Yet there was also a feeling from the groups that more could be done in school to make science and maths more appealing to girls, so that they were more likely to recognise aptitude in these areas and therefore to pursue engineering as a career. For example:

'I would say that maybe high schools need to make science and maths speak to girls more or I don't know like I suppose you can't make a girl like maths and science if she doesn't have that aptitude for it.'

Experiences studying engineering at university

Across the five different universities represented through the graduate groups, there were a number of common themes that resonated. However, there were also some interestingly different experiences articulated by participants from different institutions.

When asked whether the experience of studying engineering education was what these graduates had expected, a number of the participants highlighted the vast differences between what they had been anticipating and the reality of the situation.

One from the perspective of it being much harder than he had thought:

'My first year of Uni made me hate engineering and made want to quit. I really disliked it. It was just the move and the jump from high school curriculum to uni curriculum was huge and I feel that it was way beyond what was necessary for the workforce to be honest'

Another in the same session with the opposite experience:

'As opposed to what you said I felt like we where spoon fed in the first year. I was expecting this huge jump from high school because I found high school challenging doing hard subjects then you get to uni and first semester it felt like a revision semester.'

When the discussion changed to talking about what was taught, the graduate participants were in almost unanimous agreement that there was a significant focus on the technical side of engineering, but a distinct lack of practical application:

'If you go to the uni I went to there is pretty much nothing with regards to actually doing it in real life. It's very theoretical and there was pretty much no deviation no movement. I think we maybe did one to one and a half units based on actually how you would go about doing this if you where to get that problem in real life.'

'I kept expecting to get more practical but you know maybe in the second year would be more practical, more sort of focused on what you were doing as an engineer but it kind of got to the end of your degree and you where like oh, that never really happened'.

'I don't think you got much of an engineering sense of judgement out of it as well, so like real life practical decisions you know they are not going to be to like eight significant figures or whatever a uni problem would dictate.'

'Yes they did teach you more advanced technical and practical stuff towards the end but you still didn't get as practical as I would have liked. No sort of industry based up to date type stuff, it was all very theoretical and this is what's happened for the past 50 years it's just how it's done.'

One graduate had a slightly different experience to the others, studying at a 'Technical' university; she felt there was substantial effort to make curricula relate to the real world:

'In my uni there were a series of subjects called Engineering Practice. Each one was very focused on how things would be done in the workforce so you're given this problem at the beginning of the semester and you have to work with your team to find a solution and then present to the client who is the lecturer. And yeah that was less focused on technical things like you know technical calculations and stuff and more on kind of concepts I suppose. So it was good to have that mixture 'cause that kind of teaches you a different thing to practicing your technical skills.'

Some graduates mentioned the Engineers Without Borders (EWB) Challenge that students could participate in as being really beneficial. All the participants in the Melbourne session had been part of an EWB project and were full of praise:

'I was motivated by a lecturer and researchers to do the EWB challenge and I saw how effective that was in preparing those different professional skills.'

The main issue with this is that it was not a program done by all students or expected of students, at best this appeared to be an elective subject.

On the more practical aspects that were included in the courses – specifically Work Integrated Learning (WIL) practice – the graduates began to differ slightly in their opinions and experiences. This discussion begins with WIL on campus, then about off-campus WIL activities.

Incursions into the university were almost exclusively in the form of guest lecturers, generally people working in industry. These incursions tended to be common across all institutions and across all years of the degree. Some of the graduates saw these lectures as particularly useful due to the fact they offered some real world applications of what was being learnt:

‘it was very valuable, they give you their perspective on something that you’re learning so you get a real life view of what’s happening, so very useful’.

‘One subject that I had towards the end of my degree basically was taught by industry. There was pretty much only one lecturer who came in for maybe three to six lectures and the rest was given by a professorial fellow – who’s not technically a professor – he volunteers his time. And the others were given by people around the industry. And those same people were the ones who were taking the tutorials and the labs for that subject... But then there’re others which had no real involvement and then there’s some which had a little. I guess the one with the most industry involvement was probably, whilst it was one of the harder ones to a degree, it was the most fun as well’

Other participants were less generous about the industry involvement in teaching and lecturing. A diplomatically articulated opinion on this topic included:

‘We did have a couple of cases where it was a bit disjointed so the lecturer would explain this person’s coming in to speak about this but then they’d come and they’d give their perspective but it wasn’t necessarily connected in any way to our subject.’

Less diplomatic accounts included:

‘In our third and fourth years a guest lecturer for a drilling engineering unit ... and they gave the same lecture for both units so we were like “yay industry involvement”. Really boring lecture with all these photos and this is what it’s like on a real rig but you know he wasn’t really that helpful.’

‘We had a few guest lecturers but the majority of the stuff they spoke about was really boring. Some of the blokes they got in where absolutely useless, I don’t know why they did that, there was this bloke who had no idea how to use a programme he was meant to be teaching us on so that was pointless’

Opinions relating to opportunities for industry-based projects (or project work at least linked to industry) were more universally positive. Most participants had either been involved in specific industry-related projects or had been given the opportunity to choose from a range of projects that included industry links. In general, these projects were organised by professors and teaching staff at the university, encouraged group-based work and tied into solving real world problems.

‘Generally what happens is there’s the supervisors, lecturers, will say these are projects that I have and then people go “Oh I want to do your project. I did these subjects. Do you think that’s okay?” etc. In my area – power, you were encouraged to be able to come up with your own.’

'It was set out in a way where the lecturer would send out a document with all of the supervisors at uni and all of the projects that they're running. And I think it might have said which ones were industry based. Then students would choose... [But even for the non-industry based topics] I kind of got the impression that a lot of the lecturers were encouraging people to get industry involvement in their projects even if it wasn't explicitly stated.'

'I actually got my topic when one of the lecturers sent out an email saying "I have this industry based project on dams" and cause I was working at a dams company at the time I said "Yes, I'll do it!" so I didn't have to go through the choice of looking at all the supervisors and the projects and everything.'

Interestingly, some participants were engaged in such work from the very start of their degree:

'We were put into project groups on the first day... I can't remember what the problem was now but we were given a problem that would be our project for the rest of the semester and it was very...focused on kind of a holistic view of, you know. There's this environmental problem and we have to find a solution.'

While others didn't see this sort of activity until towards the end of their degree:

[In reference to the comment above] 'I don't remember getting that at all. I remember the first semester being very focused on just do what you did that week.'

'For me, it wasn't so until the later years so maybe until third, definitely fourth year there was group... you have to do a design project that was definitely group based but earlier years, not as much teamwork, if any.'

While there is a limited sample of institutions in these focus groups, the tendency was for the ATN universities to have more of this practical application early on, while the Group of Eight seemed to have not introduced this until further on in the degree.

In fact, there were some patterns in the experiences of graduates from the 'research intensive' universities that were different to the 'technology' universities. Alongside the later introduction of practical, industry-linked projects in the research intensive universities, graduates also tended to have mature-age less formal support from their institutions. This was generally articulated by participants in terms of the organisation of first year. In general (and again highlighting that this is not a representative sample), the graduates from technology universities tended to have been allocated to small groups very early on in their degree, where as the experience at some of the other universities was much less pastoral.

For example a graduate from an ATN university described the first semester as follows:

'In first semester, they put you into groups so you were doing the same thing in the same classes with the same students. So there were 1,000 students overall, but you would do classes with thirty other students.'

While, a graduate from a Group of Eight university responded to this with a different experience:

'In regards to what you [other graduate] were saying having small classes – ours were always massive. We would have over a 1000 people at some lectures, every major class

would have generally two that would re-sit the same lecture just because everyone in the first year was just clumped together.'

Placements are an important aspect of an engineering degree, with students required to attain three months industry placement during their degree. In the case of the participants in these focus groups, all industry placement was expected to be undertaken outside of semester. All placement organisation was the responsibility of the individual students, and there was limited support from the universities in this (at best this involved directing students to employers who potentially might have opportunities for work experience). A couple of the participants in the focus groups had assistance in their placement finding through specific scholarships (some through university and some through employers) which essentially guaranteed placement for these students from the start of first year, thus eliminating the 'stress' of finding such work independently. While these two examples showed that there are good opportunities for some engineering students to secure support this way, it appears that these positions were relatively uncommon.

All participants in the focus groups had successfully secured placements in industry through their degrees and while indicating that gaining these placements had generally been a stressful experience, suggested that most of their peers were able to find placements as long as they 'applied themselves' to the task early on in the degree. It appears that those who were least successful in finding placements were those who were 'lazy' and left it until the last minute: *'Yeah so obviously you'd get the lazy people who wouldn't apply for anything then wonder why they didn't get anything.'*

The graduates involved in the discussions were unanimously positive about the experience in undertaking work placements and in the benefit these were in gaining employment after graduation (this latter point is covered in the following section). There was common acceptance that doing 'vac work' (vacation or placement work), was part and parcel of doing an engineering degree, *'the uni did enough because you know I don't think it should be up to the uni to give the students work'*, with no questioning of why it was that it had to be outside the semester time.

However, some noted the fact that the engineering experience was quite different to that for other professional degrees in terms of work placements:

'I would say that there's very little support in finding work experience. It's very much sort of "You are required to do work experience so you should start applying for jobs." It's very much like that. It's not like in teaching or nursing where the university finds places for you. You pretty much just have to apply for positions or utilise any contacts that you have, just anyway that you can find to get the job. In terms of support, the only support I'd say that the university gave me was they'd send emails saying, you know, "Exxon Mobil is coming to our career's expo and they've got places open and you should go and speak to them."'

As articulated by a participant in the Melbourne session, many of the placement applications were as strenuous as an actual job application:

'The process of applying for work experience is enormously time consuming, so a lot of my friends were spending every night applying for work experience, especially with big companies where they have extremely rigorous selection criteria. You'd waste all your time applying for work experience and not actually do homework.'

However, there was some mention of programs set up to make the process more efficient and flexible:

'I think there was one program. I think it was called the Foresight Program. I think it was a bunch of contractors get together and offer work experience to students so I think you can go into this Foresight Program's meeting thing and you'd interview, just a general interview, then the contractors would choose who they wanted out of the group so that was a good way to or a good tool in getting work experience.'

3.3.3 Commencing in the engineering workforce

As noted earlier, almost all the engineering graduates involved in the focus group were employed, with the only one not currently in the engineering workforce undertaking a PhD in engineering. Participants had been working in the engineering workforce on a full-time basis for between 3 and 12 months, so all were very new to this career. While new to the job, these graduates could all be considered as 'successful' – in that they had all gained employment very quickly (and in some cases, before graduation) in what seems to be a highly competitive environment.

Finding employment

When asked about the options they saw for themselves on graduation, all employed participants emphasised that they had been committed to finding an engineering job in their field – in other words, none had 'second thoughts' about whether the engineering workforce was where they wanted to be. In general, gaining employment in the engineering workforce was seen by graduates as a difficult and complex task. Job searching techniques appeared to be relatively 'random', with most of the graduates involved agreeing that they had basically used a 'scatter gun' approach to applying for graduate jobs:

'In terms of the graduate applications it was just a blanket application to every oil and gas company that I knew that had a graduate programme that would be taking applications. I applied to every single one.'

'Yeah, just apply online everywhere that I was eligible to apply for and went to a few interviews at a few different companies and went to a few different assessment centres and just the pretty standard recruitment process really.'

While not all the graduates were in specific 'graduate' positions in their current work, all agreed that the sole focus when looking for jobs was in applying as a graduate for formal graduate positions or positions that were clearly designed for graduates. Most, if not all the major engineering firms in Australia have streamlined, online and detailed application forms for graduate positions. All employed participants in the focus group were familiar with these, and suggested that most, if not all, of their classmates applied for graduate positions using such avenues. These application processes seem to be like a 'mass production' way of recruiting, and often operate like a 'black box' for graduates who apply – they send them in and have very little idea of where they go or what the outcome will be. One graduate described a case where a large company's online graduate entry forms were active and people were going through the process of applying, only to be told sometime later that the company was not actually taking a graduate stream that year:

'I actually heard one company, I won't name which one, had their application process up and running even though they had decided that year not to take anyone.'

For some of the graduates, the scatter gun approach was the main method they employed in finding a job – and for them, it worked. Two in particular had secured graduate positions in large multi-national engineering firms in their field. Others had managed to secure work by using contacts made during placements and vacation work. A couple of graduates were now employed with the same company that they had been in during their placements:

'I did work placement with my employer kind of two or three days a week throughout the year and I think it was about in April or so that I started hinting that I would have to start applying for other jobs (when I didn't really want to cause I was enjoying myself there) and that kind of whipped my bosses into gear and they offered me a job. And then I started in February as a full time graduate, but yeah it's not really a structured graduate program, it's more just I'm another worker and my title is graduate.'

'I did the three lots of work experience and then throughout the whole of last year, I did the same thing [as the person above]. I was like "Look, graduate positions close in like March...I have to start applying now". I got interviewed for a position with them that never had actually opened as far as I was aware. They just interviewed me anyway.'

In these examples, the graduates found themselves in interesting work, but not in the formal graduate streams that others had moved into.

Types of work and job security

Graduates employed in specific graduate streams were employed by large companies with a formal pathway set for working through the company, beginning in a graduate program that involved rotations through different parts of the organisation in order to learn a broad range of projects in the initial years.

As noted above, other graduates, not in formal graduate positions had a slightly different type of introduction and learning – seemingly more settled in the specific discipline or speciality:

'...I think there was talk of if other groups need someone they might put me around but I think my boss wants to keep me in dams because we're so busy. And I'm happy to stay there.'

Most of the employed graduates were in relatively secure positions, with little or no apprehension stated about job security or ongoing work in their company. However, one participant did find himself in a more tenuous position. Having gained 'really interesting' work in a company that he had spent most of his placement time with, and despite feeling 'well supported' by his manager, this graduate was currently working on one three month contract at a time. While he was enjoying the work enough to be committed to the company, he knew that if 'the next project' did not come through, he was the first in line to not have a new contract. A conversation with this graduate about this predicament is below:

Graduate: So I'm a contractor...not even rolling contracts. Sometimes I keep working when I'm not under one and then I get the contract a few weeks later.

Facilitator: Do you find that precarious?

Graduate: I do. I'm not saying I'm a big fan of it. I've pushed for longer and my boss has pushed for longer but purely because of headcount they can't give me anything else so it's just the position I'm stuck in unless I go for another job.

Facilitator: And is that a consideration?

Graduate: It has been. They've been great helping me learn throughout the whole time that I've been there and my bosses especially have been pushing for me to get projects

that help me learn things that I've never done before so it's kind of hard to want to leave. But at the same time, I can't expect it to happen but yeah it has crossed my mind.

Facilitator: It sounds hard to plan or think about it from that perspective.

Graduate: It is when sometimes I don't find out that I've got another three months until a couple days before my contract ends. It can get quite, yeah, hairy, is the understatement, I guess.

Reflecting on employment prospects

The participants in the focus groups were asked about the outcomes of their classmates in securing employment. For some, basically everyone who graduated was now employed 'I don't know anyone in my year that didn't get a job', for others they saw many of their classmates struggling to find employment 'only 20 to 30% of my graduating class that managed to find a job, it's increased through the graduate application programme processes it increased to probably 40%, maybe 50%, but there is still certainly plenty of people looking for jobs'.

Numerous explanations were given for the issues faced by classmates not finding work. Most common was laziness, which had stemmed from not getting placement work during their degree. However, there was also some discussion about the difficulties in securing work now, compared with when these graduates began their degrees.

'I'd say it's definitely more competitive now like when I first started my degree, at one of the Engineers Australia career's expos or something like that, you know, we were given flyers – "80% of civil engineering graduates will get jobs from their work experience and we have a shortage of civil engineering graduates" and things like that. And yet a couple of years later, no one could find work experience so I mean I know that my boss had to really push higher management to hire me. Yeah so it's pretty hard.'

'I think that [problems with graduates finding employment] is just going to compound the further it goes along as there is still more a lot more people going into engineering from we see in the lower years, there is the same number of jobs available each year or less...'

'I think I can from what I know, mechanical's a little bit harder to get into in terms of getting a job. In terms of electrical, most of my good friends have jobs but it really depends and I know a lot of people who don't have any. Some had to take fly in/fly out jobs but that not being their preference because I guess the mining jobs are easier, there's more on offer. But there're a lot of people who don't want to work for the... I guess you call the gas or fracking; they're not particularly fond of it so they don't want to be using that as their source of income.'

There were also more general issues highlighted by graduate participants about the competition for engineering jobs currently. Two themes emerged in this regard.

One that graduate positions were not necessarily being taken by new graduates, but by people who had qualified up to three years earlier and were switching employers or had taken short-term contract work and now had extra experience to give them an advantage:

'they [graduates from a couple of years back] get a lot of field experience within their first one to three years out and then because they are still eligible apply with x number of years field experience to these graduate positions and are very successful.'

'I would say 70% of applicants would probably be graduates but a lot of the time I mean, I met a couple of people at my assessment centre for Woodside that had a PhD and two where masters students as well so it's not just Bachelor Graduates it's high level graduates as well.'

The other was that there was a perception that the demand in engineering was all for mature-age engineers and not for graduates:

'I get the impression that experienced engineers are more in short supply than graduates. I'd say there're too many graduates at the moment and its experienced engineers that are required.'

Employer expectations

In the experiences of the graduates involved, expectations of their employers on their work seemed to be reasonable. None of the employed graduates expressed feeling out of their depth as a result of the tasks given to them in their work, indicating that in general their employers seemed to recognise that they were graduates and were still learning to be engineers.

'I think in some respects they are reasonable...they [employers] can put you in an area they think you will be right based on the skills you have shown in an assessment centre or something like that and the vac work that you have done and your transcript but they still don't really know your true capability but I suppose it's more that they know you are capable of learning and that if they put you somewhere that you are interested in that they think there is a business need for it you will be able to learn on the job and eventually do your job well.'

There was also recognition among graduates that expectations are different depending on the employment context, one graduate described how this was the cases even within the one organisation:

'Grads get moved every six months to a new role so I know people who have gone into roles where the engineers expect them to know absolutely nothing and teach them, and other people have gone into roles where they expect quite a bit of prior knowledge.'

And, a recognition that graduates themselves needed to adapt what they had learnt to the workplace environment and seek answers if needed:

'In the role that I am in I don't think I am particularly prepared for what I am meant to be doing but I have enough general knowledge from uni to have a grounding and an understanding for what needs to be done, and realise that I don't know enough so I need to find people to talk to that do know and can help me at the start anyway.'

3.3.4 Reflections on engineering work

Support and professional development

The employed graduates appeared to be relatively comfortable and happy in the employment they had found on graduation. Support networks were particularly strong (or at least more visible) for those employed in specific graduate positions, with these graduates involved in numerous courses and professional development opportunities.

Professional development was also something that the graduates saw as part of their own personal responsibility to maintain. Most participants were members of Engineers Australia and actively pursued development opportunities through this group. One graduate in particular mentioned that he was actively seeking EA activities in his first year out of university as a way of networking more widely and getting a better grasp of the wider workforce.

Workplace culture

When asked about the culture of the workplace they were in, graduates were relatively positive about the attitudes of employers and co-workers. Being young engineers seemed to not be a significant problem as most felt they were respected and supported to learn more on the job. However, one graduate did indicate that he felt there was a bit of pressure to ‘prove yourself’ early on:

‘Grads are not given say as much respect when they start. In construction you sort of have to prove that you know what you are talking about than automatically give you responsibility and respect. But as you know that comes with every role so you really do have to earn it build relationships with people which is not necessarily easy and then I guess after a while they will respect and value your opinion....’

The female graduates were optimistic that some of the issues faced by women in the past were being addressed and making the environment more encouraging to women.

‘If anything I’ve been advantaged because I hear companies want women.’

‘The company I am at is really big on diversity and inclusion. They have a million policies about it, and our area is about 50% woman graduates so they are really serious about equality and inclusion and also talking about barriers for woman as they get older or mature people. I know a lot of companies that are like we are but this is the first company that I have seen that really embody that like, every now and again you will see you know you will be looking for someone and it will be, no they are working from home today, so they are really flexible about working from home, working flexible hours, working part time.’

On this topic, one male graduate has an interesting story about the recruitment practices of one company:

‘I can tell you from going to a grad fair this year and being a person giving out information that I was told by our recruitment that “we are very interested in girls only”, and they were not really interested in guys at all.’

Reflecting on recent experiences and stories from others, one graduate spoke about the competitive culture and the fact that ‘women being smart’ was sometimes an issue – a challenge she rose to, but perhaps others wouldn’t:

‘I’ve never really encountered any problems being a female in engineering. I have heard stories from other female engineers in my office about kind of a few of the older engineers being a bit sexist and thinking female engineers can’t possibly know the right answer and stuff like that and I suppose I got that occasionally in uni ‘cause I was a high performer, it was usually other high male performers who said “That’s not right. You’ve done it wrong” and then it turns out that I was right. But you don’t really let it get to you. I mean I didn’t.’

In the minds of the graduates involved in the focus groups, there certainly appeared to be differences in attitudes towards women across different disciplines. The reflections of the male participants drew these issues out further:

'I think my workplace seem to be pretty supportive of women but the area [petroleum] that I am in still tends to be a bit of a boys club. So you know there is more swearing, they are a bit rougher and similar to I suppose you see as a stereotypical engineering office and things like that..'

'Construction is very male dominated. I think there is a lot of pressure on the women to sort of prove themselves that they sort of handle the guys because they do cop it a bit I think a little bit but you have to sort of be ready for that. I think to be honest the guys cop it too but women especially are probably under a little bit more pressure to perform and there is probably more barriers for women.'

3.3.5 Progression and advancement in engineering

All the participants in the graduate group were by definition new to the profession. They had all only recently secured their first full time job in the engineering workforce, and in general, seemed to be just recovering from this significant milestone. As such, discussion and elaboration on advancement through the engineering workforce was relatively limited in the focus groups. It was those in the specific graduate programs that seemed to have the most perspective on the progression and future opportunities.

When pressed further on this, there was some discussion among graduates about the impact of 'office politics' on advancement:

'I don't know but there seems to be a lot [of high level managers] saying one thing and then delivering something completely different...and certain people that have come into the area will promise certain things and training to get them up to speed but now that they have started they are sort of just treated like second rate citizens and it's not what they expected at all and it's not what they were told. So it seems like you kind of have to play the game regardless if you want to move up whether you like it or not... you need to be friendly with everyone but at the same time it's very, very competitive.'

And also some scepticism about 'jobs for mates' by one graduate:

'...there's a lot of jobs for mates, especially I work with a lot of ex pats from the UK and a lot of people seem to know each other very well or have worked with each other in the past in the UK. So some of it you don't really know if they have sort of brought their mate out or not which is a bit iffy.'

3.3.6 Examples of best practice approaches

The approach to developing practical skills and facilitating transition to the workforce were of crucial importance to the graduate engineers that participated in the focus groups. As such, the focus of this final section is on some examples of programs mentioned during the discussions that facilitate these things.

For building a practical and project-based experience among new engineering students, there was overwhelming support and fond memories of the Engineers Without Borders (EWB) Challenge that many of the focus group participants had been a part of as students. This program was used by the participants as an example of good practical application of learning in engineering.

One graduate, from RMIT, impressed other participants in her focus group when she explained how she and her classmates were given an engineering ‘real-world’ problem to solve (over the course of the semester) on day-one of their course. The experience with this project, and others that were ongoing throughout the degree was seen by this graduate (and the other graduates listening) as a really good way of combining the practical with the theoretical; while the majority of the on-campus learning was theoretical, the students always had this project in the back of their mind to solve based on the theory and content from the lectures during semester.

In terms of providing better opportunities for work placements (and often graduate jobs), the existence of scholarship programs seemed to be of huge benefit for those students who were chosen for them. In each of the focus groups, one of the participants had benefitted from a scholarship which set them up with an employer for placements (meaning they avoided the difficult task of finding placements during study) and eventually lead to employment possibilities. The Leadership in a Technological Environment (LITE) program at Monash University, offers one example of this raised by one of the graduate engineers.

3.4 Senior School Students

Summary of findings:

- Overall, senior school students involved in the focus groups were relatively well aware of what engineering is and what engineers do. In some cases the wide variety of roles for engineers was very well understood.
- Many of the students knew about engineering through family members who were engineers. A few also knew about it through participation in school and extracurricular careers activities.
- A strong link between interest in (and aptitude for) mathematics was made by school students.
- A particular appeal of engineering highlighted by students was the real life problem solving aspects of engineering occupations.
- Awareness of the educational pathways required to enter the engineering workforce were broadly known by students, although some of the detail relating to entrance, length of courses etc. was less well understood.
- Careers advice and booklets provided to students were not seen as very helpful, instead the experiences of the students suggest that real engagement is more visceral. As such the inclusion of hands-on, visible activities, and role models (family members) in engineering are important for sparking an interest at this level and earlier at school.

3.4.1 Background

One of the major difficulties in inspiring school students to consider engineering as a career is their lack of knowledge and understanding of the domain (Dawes & Rasmussen, 2007; Richards, Laufer, & Humphrey, 2002; Hirsch, Carpinelli, Kimmel, Rockland, & Bloom, 2007 cited in English *et al.* (2011).

Few studies have probed students' understanding of what engineering entails, of what engineers do, and of the uses and implications of the technologies that they generate (Cunningham & Hester, 2007; Knight & Cunningham, 2004).

A recent Australian study by English *et al.* (2011) sought to gain insights into grade 7 students' initial knowledge, awareness, and appreciation of engineers and engineering. The responses indicated that the students had broad understandings about engineers as construction designers who solve real-world problems to assist the community. There was a strong focus on large constructions.

The following results from focus groups of senior secondary school students in Sydney and Melbourne seek to provide further insights into student perceptions of engineering.

3.4.2 Participants

a) *School 1*

The first focus groups were held at a large independent boys school in Sydney. The school offers both the Higher School Certificate (HSC) and International Baccalaureate Diploma

Program (IB) for Year 11 and 12 students. Although VET options are available, more than 90% of students go on to study at university.

Students from Years 11 were selected for the focus group based on their participation in STEM-related subjects in the IB, such as the Design Technology. The course includes: electronic product design; computer-aided design/manufacturing; food science and technology; textiles; and human factors design.

The sample was split into two groups of 7-8 for the focus groups.

b) School 2

The second focus groups were held at a large government secondary college in Melbourne. The school offers Victorian Certificate of Education (VCE), VCAL (Victorian Certificate of Applied Learning), VET in Schools and School-Based Apprenticeships (SBAT). The school also has a specialist maths and science stream. Around one-third of students go on to university and a slightly lower proportion goes on to VET studies.

Senior students (Years 10 to 12) were selected from two groups: those who are currently studying towards the VCAL – these students are at various stages of completing their Certificate I and/or II with a pre-apprenticeship in an engineering-related trade, with disciplines such as automotive (both car and heavy vehicle), building, construction and electrical represented. The other group was selected from the specialist maths and science stream.

The VCAL group comprised of 8 students and the maths and science students comprised of 7 students. This second group included two female students – the only females involved in the school focus groups.

3.4.3 What is engineering?

General perceptions of engineering

This section sought to explore student perceptions of engineering in terms of: its general features; skill requirements; occupation types; type of work; and possible employers.

a) School 1

The awareness of ‘engineering’ varied a great deal between the two groups at this school. The first group had quite a limited understanding of what engineers do and were not fixed on pursuing an engineering career. In contrast, the second group showed more interest and were able to associate engineering with ‘building’, ‘fixing’, ‘problem-solving’, ‘designing products and projects’ and ‘supervising’. In a more tangible sense, they associate it with ‘engines’ and ‘buildings’, ‘houses’, ‘roads’ and ‘bridges’.

‘It’s like taking an architects’ plans and like mathematically actually solving it.’

‘It’s like the mechanics behind how things work, so it’s like very physics and maths based, like structure and stuff.’

Perhaps reflecting the context and curriculum of the school concerned, this group had quite a good understanding of different types of engineering. The students were able to provide examples such as ‘civil’, ‘aeronautical’, ‘electrical’, ‘biomedical’ and ‘mechanical’. There

was also some awareness of the breadth of employer types, for example, those who are: contracting engineers to large multinational organisations; self-employed as ‘tradies’; and those who work collaboratively with designers and architects.

‘Say with cars for example, they’d work in conjunction with designers who design the appearance. And they have to design how it works.’

The second group (those who were thinking more about engineering) also associated it with ‘design’, ‘planning’ and ‘creating’. There was an impression that engineering can connect with ‘future’, ‘invention’ and ‘new technologies’.

b) School 2

The students enrolled in the Victorian Certificate of Applied Learning (VCAL) were each undertaking pre-apprenticeships in a range of engineering trades including automotive, electrical and carpentry.

These students perceive engineering quite differently from the first school in that only one had considered a university pathway as an option. Their perception of the engineering profession is framed by the jobs and employers they have already been exposed to, either through family and friends, or as part of their apprenticeships.

Words associated with ‘engineering’ were ‘practical’, ‘real-world’, ‘machines’ and ‘design’. The students doing a pre-apprenticeship in automotive were interested in the design elements in areas like exploring new technologies e.g. self-parking cars.

Among the group of students for School 2 who were in the maths and science stream, the impressions of engineering were similar to those from the School 1 group. Students mentioned the fact that engineers ‘solve problems’, ‘make and design things’ and are generally necessary across a range of areas:

‘Well what I think engineering is just trying to make things work and just that pretty much. That’s my understanding.’

‘Nearly every job in some way you can use an engineer. Even if it’s got to do with food I am pretty sure like chemical engineering and stuff they would need it there so anywhere really.’

A couple of the students in the group used the example of an aeroplane to explain the different sorts of things they believed engineers did, and the different specialities of engineering. This discussion, instigated by the students, showed a good knowledge of different disciplines and the application of the disciplines to contribute to the design of a plane. Areas such as aeronautics, mechanics, electrics, materials, computing, robotics, fuel and manufacturing were all covered by the group through this example.

Overall this discussion led to the conclusion from one student that:

‘I don’t really see where engineers wouldn’t be useful’

Information and advice about engineering

Personal connections or associations with engineers can influence a student’s perceptions of engineers and engineering (e.g., Davies, Spencer, & Steele, 2005; Eccles, 1994). This section sought to explore student perceptions of engineering, in terms of how they learnt about it; the role of careers counselling; their participation in engineering events and programs; the role of

STEM subjects in stimulating their interest in engineering; future study plans; and family/peers perceptions of their interest in engineering.

a) School 1

Several students were able to identify engineers they knew, particularly those in their families (also found in English *et al.* 2011). Family and friends are influential role models and sources of information and advice. The perceptions of engineering, as identified above, can originate from occupations and espoused views of parents or other family members.

Word-of-mouth from family and family friends (usually fathers, older brothers, uncles who were/are studying/employed as engineers) were the main sources of information. However, careers advisors, TV/internet, year-level co-ordinators and science teachers were also listed by students as information sources.

Vocational testing has been used at the school to assist with informing students about their skills, aptitudes and interests in particular fields and *'find out what we'd be suited to'*. In terms of events and presentations one student commented that *'they gave a brief overview of a range of occupations. Engineering cropped up in that talk.'* There was an impression that events occur fairly infrequently and that there is an appetite for more.

'If someone from a Uni came, like someone who actually does the job that you're looking forward to and they come and give a presentation, power-point or something like that, that gives you details about what the job entails and what you have to do. That would be pretty helpful.'

'When there's an event, you get a bit more motivated, and you actually think about it.'

In terms of careers advice, each student was allocated an hour and received *"a booklet about different universities and marks you need to get and assumed knowledge and just talks about the various options"*. Engineering was presented as one of a number of course options to consider at university. At this particular school, 'careers advice' was perceived to sit more in the domain of VET and careers in the trades than those seeking a university pathway.

b) School 2

Most of the VCAL students had friends or family friends who were employed in the trades. These locally-based family and social networks were a vital means of connecting these young people into their pre-apprenticeship work placements. This was seen as being more ideal than approaching employers 'cold' to commence a pre-apprenticeship.

Their reasons for pursuing pathways into automotive engineering include:

'Just the love for the vehicles. Just the general curiosity about how they work. How modern technology's changing.'

'My Dad's just been driving trucks since I could remember so I've been around them for a bit and I just love being around them, the noise and everything.'

There is a career advice service at the school but there is some concern that VCAL students are considered a lower-order priority in favour of those intending to enrol at university and those doing school-based apprenticeships (which was the opposite to school 1).

The maths and science stream students at School 2 tended to have become aware about engineering occupations through involvement in extra-curricular activities run through the school or the local municipal council. Unlike the academically-oriented students from school 1, most of these students did not have relatives or friends in engineering occupations on which to build their perceptions of the profession.

A number of these students had attended careers events run through the local council in conjunction with universities that provide access to a range of different occupations and industries. Most of these students had an interest in mathematics and were therefore interested in the 'leap into engineering' displays that were part of the career event. They had learnt through this particular event the different facets of engineering, particularly through a robotics display. The information gathered through the event had also given the students insight into civil engineering through town planning etc.

3.4.4 Educational pathways to engineering

This section sought to explore student perceptions of educational pathways into engineering, including: how their current subjects connect with future studies; clarity of the engineering pathway; and exposure to university/TAFE information and advice. In general, many of the students involved in the focus groups indicated an interest, if not intention, to follow an engineering pathway. While for the VCAL students, this was already a reality, among the other school students, some of these decisions were still (in the minds of these young people) a little way off and as such, few (if any) had made any solid plans in relation to future study or work choices.

Practical application of concepts

a) School 1

Students across the classes recognised that mathematics and science are key subjects for a career in engineering; with some mentioning 'design and technology' as providing some foundation knowledge.

There was interest in understanding how theoretical concepts learnt in maths classes can be practically applied, for example '*in maths we always ask, like, "What is the practical application of this?" and sometimes he tells us*'. However, another student commented that '*it's mainly when kids question the teacher why it's useful.*' and that '*they mainly concentrate on teaching the course, not how it relates to real life or jobs*'.

'I think that [real-life application of concepts] would help when choosing or deciding what job you want to do or selecting subjects for years 11 and 12. You'd sort of have a better idea of what would be more helpful for you when you go into Uni, if you have a particular job in mind.'

'I think with choosing a job, you haven't any idea of what it actually entails until you see what people do. And we don't see what anyone does; we're sort of just making an assumption on what other people have told us about it.'

The issue of practical application of concepts was seen as being somewhat important, for example: '*with geometry in maths, you need to know how shapes inter-relate so I'm guessing that's very useful and helpful for engineering.*' Another student commented that '*in year 7*

Design and Technology, there was some... when we did woodwork and all that, sometimes metalwork, there were a few references to engineering.'

b) School 2

The VCAL students are working towards a Certificate I and/or II in their respective trade. They could only see some limited connection between the mathematical concepts they had learnt in secondary school to what they were doing at TAFE and on the job site as part of their pre-apprenticeship.

'Well maths and numeracy skills are always essential for whatever you're doing but when in Year 7 and 8 when we did food tech and woodwork I enjoyed them a lot more cause I wasn't just sitting and listening to a teacher talk.'

On the other hand, the students in the academic stream emphasised the theoretical nature of engineering and thought therefore that the mathematics (and to a lesser extent science) subjects that they were doing at school directly related to engineering work.

'A lot of people think engineering is a lot more the actual practical side but I think there is a lot more theory to it. Like it's all about trying to make it work on paper first then trying to actually make it work in real life'

Linkage between school subject selection and engineering pathways

a) School 1

There was a general agreement that 'maths' is necessary to perform well in an engineering course at university and equal agreement that it is "the least motivational subject". The recent removal of pre-requisites for mathematics, in favour of 'assumed knowledge', to gain entry into engineering courses at university was a particular area of interest.

Male student: *'[There aren't] really any pre-requisites [for university], just assumed knowledge. They say we assume you've done the subjects at this standard. So if you choose those subjects then it helps you in your first year.'*

Facilitator: *'So would you consider going into engineering do you think without the maths?'*

Male student: *'it would be a massive hindrance, because you'd have to catch up at uni...'*

Coinciding with the vocational testing and university presentations at schools, students have explored university websites and course guides. However, they were unsure about how the description of course units at university connect with their current subject selection at school.

Importantly, most of these students were undertaking 'Standard level' Mathematics as part of their IB, commenting that although it equates to 2 units, they believe it to be very challenging and more equivalent to 3 units. There was a general uncertainty about the extent to which higher levels of difficulty in maths subject selection at school has a "pay-off" at university. There was an appetite for information about why one should take the quick and easy path "Studies" compared to the more difficult, higher level subjects:

'The main reason last year that our teacher told us not to do "Studies", because, you'll get bored with the course and if you want to do engineering, you'll fail the first year, no one's passed the first year if they did Studies.'

The students commented on a few different occasions about university summer and bridging programs which are available in maths and science units. There was some confusion about how these courses equate to what they are doing at school.

'They say you can do a course in-between year 12 and Uni, but it's kind of like cramming it all in, in the space of three months, rather than learning it over a period of two years.'

b) School 2

As they are currently studying at TAFE one day a week and are working on site for 1-2 days a week, the VCAL students see direct relevance to what they are learning with their future employment pathway. Their experience of learning is integrated in their perceptions of work. However, they were less certain about the linkages between what they continue to learn at school with what they are doing at TAFE and on the worksite.

The maths and science stream students at school 2 were self-confessed mathematics fans. As noted in the discussion above, this cohort saw that mathematics and engineering were very closely related and that if you were interested in maths, then a career in engineering might prove to be a good match.

'I think that we may need a basic understanding of physics to do engineering and probably doing physics in VCE would help with going to Uni and for getting the right Score and everything.'

Unlike the school 1 group, these students were motivated by mathematics and seemed to relish the challenge that mathematics offered (and saw that the challenge would benefit in the long term). Many of those in this group were still in Year 10 and therefore not yet ensconced in the potential stresses of the VCE and final couple of years of high school, but nonetheless seemed to have a different attitude to the link between school subjects and the engineering workforce than those in school 1.

VET/university pathways

a) School 1

Some students had attempted to learn more about the course units at university but were confused by the language and terminology and how it connects with what they are currently studying at school.

'I find the internet Uni websites really confusing. I looked at them and there were requirements, courses, diplomas, all this stuff and I had no idea what it was on about.'

'When they say what the course is about, they don't actually tell you the job that it leads to, and it doesn't tell you what the job itself, what you have to do and what it entails. It just gives you what you're going to learn in the course and what your requirements are, so it's kind of robotic and monotonous. Impersonal.'

'The thing that worries me is that, say you get two years into the course, and then you realise it's not for you. Although you've learned something in those two years, you've kind of wasted it if it's not the profession you're going to do.'

There was some interest in how engineering courses might be packaged with business and medical degrees. In terms of business, there was an appreciation that business and

management skills are just as, if not more, important as understanding technical aspects of engineering. This may connect with the perception, at least in the first school, that engineering is associated with large, multinational enterprise or self-employment.

b) School 2

Most, if not all, of the VCAL students did not see a university pathway as an option and had decided on VCAL as the best option for them as early as Year 9. Their intentions centre on completing their pre-apprenticeship with a Certificate I and/or II qualification in their chosen trade and then moving into an apprenticeship.

Most of the maths and science stream students were aiming to go to university following schooling, but there was a relative lack of knowledge about the specificities of an engineering pathway through university. One of the students in the group mentioned the Australian Defence Force Academy (ADFA) numerous times in discussions of pathways and careers. He had seen an advertisement about careers linked to engineering through ADFA and was attracted by the prospect of it:

'With that one you have to study at the Uni of NSW I think, and I have been looking through that one as basically you get a career when you finish Uni as well. If you do it through that you are getting paid while you are at Uni to do it.'

When asked about how they might find out more about educational pathways to engineering occupations, the group concluded that they would aim to go to university open days to learn more, but that they hadn't done that yet.

In general the participants in the maths and science stream seemed relatively keen on following an engineering career pathway, although as is apparent in the discussion above, none were committing either way at this point in their schooling.

When the females in this group were specifically asked if they perceived any gender barriers preventing them accessing the engineering workforce, there was acknowledgement that there were fewer women in the area, but not particular concern about being a woman in engineering. One of the female participants was pragmatic on this point:

'In this field you just have to get used to it because if you let it affect you..[shrugs shoulders]...you know what I mean?...'

Another female participant also said that the decision-making on careers came down to interests alone:

'Basically it's whether we enjoy it or not. I think if you don't enjoy a subject or if you don't enjoy what you do what is the point.'

3.4.5 The future of engineering

This section sought to explore student perceptions in terms of: future of the profession; future engineer career paths and skill requirements; and the extent to which the current generation is prepared for these changes.

Perception of future of engineering, job outlook and workforce

a) School 1

There is an appetite for information which describes the role of an engineer in a way that is more appealing, interesting and engaging to the target audience:

'They need to show the interesting side more, and describe accurately what an engineer does, and the different types of engineers, because we don't really know. You have the names for the different fields and skin deep knowledge, you don't know anything else.'

'I think people need to be educated about what engineering really is, at schools. I've learned more in this half an hour than like years.'

In addition to deepening this understanding of the profession, the students suggested that access and referral to information about the types of engineering skills shortages, graduate salaries and in-demand occupations would be helpful.

There was some pessimism about job opportunities in the engineering workforce.

'I've heard at least there's lots of competition to get the good jobs, so to get a good foothold after you've finished Uni, you need to score well so that companies notice you.'

'Employers are looking for experience but how do you get experience without being given a chance first? Where do you get experience from?'

'I can get a university degree but if there isn't a job....'

Interestingly, there were also concerns expressed about stereotypes and gender bias in the workforce.

'Engineering courses at least from what I've heard have a lot of stereotypes around them, so if they could advertise them a bit better they might be more appealing. From what my friends told me at least, both of them are doing engineering courses and they both told me that 90 per cent of the people are male and out of 180 guys, there's like one girl there. So it's kind of awkward like that.'

b) School 2

The main concern for the VCAL group in terms of their short to medium term futures were the wages which pre-apprentices and apprentices are paid and the costs associated with travelling to and from TAFE and work. There seemed to be considerable variation within the group depending on the employer and trade. They were quite pragmatic about their future job prospects in terms of the skills they seek to have:

'In the end, the set of skills that you learn is there for life...'

The math and science stream group from School 2 saw engineering as being important in helping to shape the future. Students were generally positive about the potential for interesting jobs in engineering and saw technological advances having a big impact. For example:

'By the way things are going it will just probably be mostly theory and there wouldn't be much practical side of things it would be more I guess automatic... For instance I just saw this thing on how they are going to 3D print houses. So stuff like that will more automated rather than the actual practical.'

One of the females involved in the group mentioned that she thought the future of engineering might be more open to women:

Female Student: *There might be more females.*

Facilitator: *Do you think there are things happening that might be encouraging females to be more involved in these kinds of occupations?*

Female Student: *I don't know but maybe more acceptance of females also.*

Facilitator: *OK, so what gives you that impression or that optimism?*

Female Student: *I don't know just hopefulness I guess.*

3.4.6 Examples of best practice approaches

The research literature suggests that integrating engineering experiences within the middle school curriculum can:

- a) help students understand how to apply the engineering design process in solving real-world problems; they learn to think creatively, critically, flexibly, and visually, and to troubleshoot and learn from failure;
- b) help students appreciate how their learning in mathematics and science can apply to the solution of important real-world based engineering problems
- c) highlight the relevance of studying mathematics and physical sciences and lead to better preparedness of senior subjects, and
- d) help students appreciate the usefulness of the various fields of engineering and the role of the engineer in the society (Kaiser & Sriraman, 2006; Zawojewski, Hjalmarson, Bowman, & Lesh, 2008 cited in Mousoulides *et al.* 2012).

The focus groups conducted for this study suggest the following approaches could be explored or more widely implemented:

- better access and referral to information on the engineering job market and graduate earning (e.g. Graduate Careers Australia, Engineers Australia);
- targeted presentations which connect the learning experiences in the school curriculum with engineering jobs – possibly presented by an experienced engineer;
- promotion of role models who represent the diversity of the population to assist with breaking down stereotypes of the engineering workforce; and
- involvement of students in 'real life' problem solving tasks relating to engineering.

4 Conclusion – synthesising the findings

This project has collected a range of experiences, ideas and opinions about the engineering workforce from mature-age engineers, women in engineering, new graduate engineers and school students. While the collection is relatively small and not necessarily representative of these broad groups, the discussions nonetheless offer some interesting and useful insights into the engineering workforce from the perspectives of these target groups. The broad opinions of these groups are detailed in the chapters above, and summarised in at the beginning of each section and in the Executive Summary. As such, the intention of the conclusion to this report is to highlight some particular issues or themes in which overlap the groups involved in the study. The discussion below is divided into a number of sections. Each section explores some of the key themes that consistently appeared across the participants involved in the focus groups. In addition, where noticeably different opinions on issues were apparent between the groups, they are also discussed here.

Pathways into engineering

Both the graduate groups and the student groups were enthusiastic in relating their first ‘discovery’ of engineering – that is, the experience in which they identified what engineering was all about. For some, this came through family and friends, but for most the stand-out ‘epiphany’-like moments were gained from seeing engineering in action through hands-on experiences initiated at engineering camps, careers fairs or open days. Most of these activities were facilitated by university engineering departments. Participants in the focus groups highlighted how these experiences provided a practical introduction to the different roles of engineers and the opportunities that could be available in engineering – particularly for those with an interest in mathematics.

The importance of enjoying mathematics was another common theme that was apparent through all the groups involved in this study. It was unanimously expressed that engineering provides a very real way of applying the mathematics taught in the classroom and lecture hall. The following sentence offers a précis of the way in which this theme spanned the groups involved in the study: Being interested in maths means that you start to think about how to apply it, and you discover engineering (school students); maths background is important in getting into university (graduates), maths is fundamental for understanding the theory of engineering (women and mature).

Engineering education

Graduates, women in engineering and mature-age engineers all highlighted the extent to which the emphasis of university engineering courses was weighted towards developing a theoretical understanding of the field, and in doing so noted the relative lack of practical knowledge development. While participants generally believed there was a good case for increasing the extent to which practice was taught in universities, the mature-age and women also noted that a theoretical foundation for engineers was paramount – and highlighted that employers should also be held responsible for developing this side of new engineers. In essence, there was a feeling that joint responsibility for education between the universities and industry should be acknowledged and practiced.

Another theme that was common and consistent between the graduates and the mature age group was that there were perceivable differences between universities when it came to the theoretical-practical balance of curriculum. On this, the research intensive universities were

seen by these groups as heavily theoretical, while it was suggested that the technology universities incorporated more practical-based elements in their engineering education.

In terms of this practice, the graduate, mature-age and women's groups all highlighted the value that placements/internships/vacation work played in the educational experiences of engineering students. While there are current concerns about the availability of placements and the efforts required to secure placements, there was no doubt that across the participants this element of engineering education was vital.

On the perceptions of engineering education in Australian universities, there was one difference apparent between the views of some participants in the women in engineering group and the graduate group. In one of the women's focus groups, the opinion that lectures and content in universities was 'cutting edge' and miles in front of what was actually happening in industry was expressed. Among the new graduates, almost the opposite opinions were expressed, with graduates speaking about having to update skills in certain engineering software programs as soon as they entered the workforce due to the fact that the university software was less sophisticated or out of date.

Entering the engineering workforce

Graduates and the mature-age groups highlighted how difficult securing engineering work was currently for those new to the profession. There was acknowledgement by both these groups that employers were desperate for specialist skills and work experience but that these requirements could not be satisfied by new graduates. This was seen as problematic given the increases in which engineering places at university had been expending in recent years.

To a lesser extent, but nonetheless still important, the graduates and the mature-age engineers also noted the difficulty faced by current students in finding placement work. Given that undertaking placements are a requirement of completing a degree in engineering, the scarcity of places and the substantial competition to gain these places was seen as an important issue needing to be addressed.

A common theme expressed by the graduates and women's groups was that being a woman was not a barrier to entering the engineering workforce today. Both groups of participants spoke of recent experiences where companies were directly recruiting women, or at least making concerted efforts to increase the representation of women in the engineering workforce.

Culture in the workplace

When asked about 'workplace culture' the graduates, mature-age and women engineers involved in the focus groups all highlighted the notable differences by discipline, employer and location. While construction was generally acknowledged as more of a 'boys' club', there were examples where this was not the case. Likewise, while some young engineers felt there was pressure to 'prove' themselves, others in similar workplaces felt very supported as they embarked on their career in engineering.

The women and graduate groups both highlighted the concerted effort by some companies to increase the representation of women in workplace, acknowledging that with this comes a culture which is more inclusive of women. There was general optimism among the new graduate women and the female school students about the future of the engineering workforce in supporting women as an important group in industry.

Engineering in the future

When ‘the future’ for engineering was raised in discussion, there were some notable differences in outlook among the groups. For example, the mature-age and school student groups differed in their levels of optimism about how the profession was perceived and the relationship between this perception and ongoing support for the profession. While the mature-age group thought engineers were undervalued in relation to their design and problem solving skills, the school students tended to have a good understanding of these requirements for engineers and were confident that these skills were recognised and seen as important.

In addition to this, while the mature-age group were concerned about the shifting of industry out of Australia (and had witnessed this during their careers), the graduates and the school students were more interested in discussing the technological opportunities that might be available in the future and linked with this, the significant role that engineers will have in helping to make these technological changes happen.

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