

Chapter 3

Education and training pathways

3.1 In this chapter the committee examines education and training pathways to engineering occupations, which include professionals/managers, technicians and trades workers.¹ The importance of science, technology, engineering and mathematics (STEM) at school is set out. The Vocational Education and Training (VET) pathway to engineering trade occupations is explained. Finally, the professional engineering bachelor degree is examined.² The committee has sought to provide a brief description of each pathway, and a summary of what is being done well in education and training where there are areas for improvement.

Science, technology, education and mathematics at school

Background

3.2 Whether an individual chooses to pursue tertiary or trade qualifications, the building blocks of education originate during schooling. Indeed, the success of students at STEM subjects in primary school and high school will fundamentally impact upon each student's options at the VET and university level. For this reason, there is cause for concern at the decreasing numbers of students studying STEM subjects in senior high school years. Engineers Australia and the Australian Council of Engineering Deans argue that by increasing STEM ability in late high school, many more students would be in a position to consider engineering at the tertiary level.³

3.3 Schooling is a responsibility of the states and territories, however the federal government does have a role in influencing policy and driving particular programs. Unfortunately the Department of Education, Employment and Workplace Relations did not make a submission to this inquiry, despite receiving an invitation. As noted in chapter 2, the committee would have found a submission from DEEWR useful, and considers that, as a matter of course, the Department should make submissions to future inquiries of this committee.

3.4 In May 2012 Australia's Chief Scientist, Professor Ian Chubb, published the Report, *Health of Australian Science*.⁴ Chapter 3 of that report deals with science in

1 Australian National Engineering Taskforce (ANET), *Submission 73*, p. 4

2 The term 'engineer' in this report is used to encapsulate persons with qualifications in any of the engineering occupations.

3 The Australian Council of Engineering Deans, *Submission 65*, pp 6–7; Engineers Australia, *Submission 67*, p. 10. This is also supported by Universities Australia, *STEM and non-STEM First Year Students*, January 2012.

4 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, Foreword, May 2012. Available online: http://www.chiefscientist.gov.au/wp-content/uploads/OCS_Health_of_Australian_Science_LOWRES1.pdf (accessed 25 May 2012).

secondary schools, and draws upon a number of other recent inquiries.⁵ Study of science subjects has been declining for a number of years. For example, during the years 1992 and 2010 the percentage of Year 12 students studying:

- Biology has fallen from 35.3 per cent to 24 per cent;
- Chemistry has fallen from 22.9 per cent to 17.2 per cent;
- Physics has fallen from 20.8 per cent to 14.2 per cent; and
- Mathematics has fallen from 76.6 per cent to 72 per cent (and in addition, there has been a shift from intermediate and advanced levels down to elementary levels).⁶

3.5 The Office of the Chief Scientist observes that despite this decline, Australian students still perform well in STEM subjects in relation to other countries. However, the Office warns that we must be careful that Australia's performance levels do not remain static while those of its neighbours continue to improve.⁷ The *Health of Australian Science Report* did identify some positive responses to the decline of STEM studies. For example the Australian Academy of Science's 'Science by Doing' program and CSRIO's Scientists in Schools program.⁸

3.6 Surveys of senior secondary school students, conducted by the Office, reveal that it is teachers who are the largest factor 'in determining a student's interest in and attitudes towards science'.⁹ In order to improve STEM participation and standards during school years, the Office of the Chief Scientist recommends that teachers need to 'interact' better with students to ensure that existing students remain interested in STEM and that other students are attracted to the subject. The survey found that students and many teachers found an interactive style of teaching, featuring student-led research, practical activities and real world examples, to be most engaging.¹⁰ However, the research concluded that many teachers took a more traditional didactic approach due to 'time and resource constraints' and, for some, because of a lack of

5 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 42.

6 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 10.

7 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 10.

8 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 43

9 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 10.

10 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 51.

confidence and training.¹¹ A further difficulty is that STEM teachers are in high demand, particularly in rural and regional areas.¹²

Initiatives to improve STEM ability in schools

3.7 The committee received evidence about a number of initiatives undertaken to engage primary and high school students in STEM subjects. The Australian Council of Engineering Deans advised that a survey conducted a couple of years ago identified 600 examples of outreach programs between higher education engineering bodies and schools.¹³ A few indicative examples are provided here.¹⁴

3.8 The New South Wales division of the Institute of Public Works Engineering Australia (IPWEA) runs a Build a Bridge program for selected year 10 and 11 high school students near Wagga Wagga. The program provides students with a three day live-in program centred on engineering. Mr Paul Di Iulio explained the success of the program to the committee during the Canberra hearing:

About 124 students have progressed through this. At this stage about 25 per cent of those have taken up the challenge of undertaking an engineering path at university, another five have taken not necessarily an engineering path, but have taken on work in local government, which has been good, and a number of them are still at school. We believe that this is a fantastic opportunity to engage with people while they are still in secondary school.¹⁵

3.9 The committee heard that, were the IPWEA to receive additional funding of \$1500 a student it could extend this program – and its success – through local councils around the country.¹⁶ The committee is encouraged by the success proportion of students who progress through the program and go on to study engineering, and would be pleased to see the program rolled out more widely by local councils.

3.10 Another positive example is the University of the Sunshine Coast's integrated learning program in regional schools. The university targets those students in regional areas who find it too difficult to attend university and assists them by sending out

11 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 55.

12 Office of the Chief Scientist, *Health of Australian Science*, Commonwealth Printing, May 2012, p. 45.

13 Professor John Beynon, President, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 31.

14 Many other examples were provided to the committee throughout this inquiry. For example, surveyors in Victoria have sponsored a program called 'Surveying: a life without limits', which involves the interaction of surveyors with school children, and a demonstration of surveying tools and work: Mr Phillip Dingeldei, Chairman, Consulting Surveyors National, *Proof Committee Hansard*, 7 May 2012, p. 41.

15 Mr Paul Di Iulio, National President, Institute of Public Works Engineering Australia, *Proof Committee Hansard*, 7 May 2012, p. 57.

16 Mr Paul Di Iulio, National President, Institute of Public Works Engineering Australia, *Proof Committee Hansard*, 7 May 2012, p. 57.

academics to work with teachers in the school. Students study up to two first year engineering subjects in late high school, which can be used as credit for those students who subsequently decide to study engineering at university. Professor Mark Porter described the early success of this program:

I believe we have run this program with great success over the last three years. Because it is particularly targeted at students with an interest in construction and construction engineering we are working with the body Construction Skills Queensland. Together, we want to extend that program across Queensland. We believe we can do that for schools in regional Queensland. CSQ, Construction Skills Queensland, is in fact considering sponsorship of those students when they come on to university. They are helping to select the students, target them at engineering and then support them at the university.¹⁷

3.11 Engineers Australia runs a program called EngQuest that is offered to primary school teachers across Australia. The program aims to assist teachers to deliver fun and interesting programs that inspire children to participate in engineering and the science and mathematics behind it.¹⁸

3.12 The Australian Power Institute collaborates with the Academy of Technological Sciences and Engineering's project which runs renewable energy projects for year 8 and 9 students in more than 240 schools across Australia. The Australian Power Institute sponsors that program and has also recently approved a solar car challenge for years 8 and 9. Power Institute bursary students, discussed later in this chapter, participate in promoting engineering to high school students by participating in the solar car challenge. Mr Michael Griffins advised the committee that:

We have made a condition of receiving the bursary that our students go into the high schools and judge the challenge. They talk about what engineers do and what they are studying at university. We try to enlighten the young people in years 8 and 9 who are struggling with how maths and science are relevant to their life. Hearing it from just recent young graduates is important; they connect, because they are a similar generation.¹⁹

3.13 The Chamber for Minerals and Energy of Western Australia praised initiatives taken by Curtin University to provide high school students with practical exposure to engineering. Mr Bruce Campbell-Fraser explained the benefits of mining camp:

Our companies are very supportive of Curtin University's focus on mining camp, which is aimed at high school students considering a career in mining engineering. We encourage them to come on-site, and they work

17 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, p. 31.

18 Ms Leanne Hardwick, Director, WA Division, Engineers Australia, *Proof Committee Hansard*, 27 March 2012, p. 6.

19 Mr Michael Griffins, Chief Executive Officer, Australian Power Institute, *Proof Committee Hansard*, 28 March 2012, p. 27.

with Curtin to be provided access. I have seen indications that about 75 per cent of high school students that go on that camp end up in mining engineering. So there are very good numbers working their way through that. Our companies are engaged through that summer break, heavily and happy. I still think there is that expectation about what working in the resource sector might be like, and work experience can help address some of that. It is not for everyone, despite their expectations about what life may be as an engineer.²⁰

3.14 The committee believes that initiatives like the ones outlined in this section are an important example of how local councils, universities, industry groups and companies can promote engineering to school children and explain, in a fun and practical way, what it is that engineers do.

State and federal government initiatives

3.15 The committee received a detailed submission from the South Australian Government, which outlined its response to the decline in STEM skills in schools and in the workplace, which was introduced in August 2011.²¹ Key strategies include a:

- STEM Cabinet Taskforce that meets quarterly and ensures that government programs are coordinated and complementary (members are relevant ministers with responsibility for science, education, skills, employment, trade, defence and mineral resources);
- STEM Skills decision making framework that meets fortnightly to review existing STEM programs and develop new policy approaches (members are the chief executives of relevant departments).²²

3.16 Some programs initiated by the South Australian Government include:

- Professional development and mentoring for science and mathematics teachers;
- Incentives for science and mathematics teachers to teach in rural, remote and low socio-economic metropolitan schools;
- Targeted recruitments of science and mathematics teachers; and
- Bridging courses for students wishing to upgrade STEM skills to pursue careers in defence related industries.

3.17 The South Australian Government noted that it was aware of similar efforts to improve STEM ability at school by the Victorian and Queensland governments.²³

20 Mr Bruce Campbell-Fraser, Executive Officer, Chamber of Minerals and Energy WA, *Proof Committee Hansard*, 27 March 2012, p. 28.

21 Government of South Australia, *Submission 43*.

22 Government of South Australia, *Submission 43*, p. 5.

23 Government of South Australia, *Submission 43*, p. 8.

3.18 In its submission, the South Australian Government reiterated its recommendation that promotion of STEM skills be discussed at the Council of Australian Governments, with a view to developing a national approach.²⁴

3.19 The Warren Centre for Advanced Engineering has criticised government responses to STEM promotion in schools. Further, career advice is usually provided in years 10 and 12, by which time students have already made subject choices which will impact their careers.²⁵ The Warren Centre suggests that the United Kingdom approach to solving STEM shortage has merit.²⁶ The Warren Centre explained that it has

...been particularly impressed by the UK Government's recognition not only of the need for a National Strategic Plan to promote STEM studies, but also the support they have provided for the mapping of current initiatives (a necessary first step in any strategic plan) and follow-through on Action Plans that, five years later, have resulted in a number of professionally managed initiatives.

We have also noted that the USA, although some three years behind the UK, is following the same course of action.²⁷

3.20 The Warren Centre calls upon the Australian government to also develop a strategic plan to address STEM skills shortages.²⁸

3.21 The committee heard that outreach should also be conducted to career advisors in schools, to ensure that students are aware of the engineering opportunities available through trade or university. Mr Dan Reeve, Capacity Chapter Member, Roads Australia considered that the solution was as simple as finding a way to communicate to students and career advisors what it is that engineers actually do:

A lot of career advisers do not really understand what is involved in being an engineer. Some people think it is an office job and all we do is paperwork; other people think that it is just being a project manager building something. You do not know the full sphere of what engineers are involved in, and, if we can get people involved in the early understanding of maths and science and how it is applied—because what we do as engineers is apply the law of physics to things and materials so that you can build things—then early they understand it and see that there are well-paid careers, and then they will take an interest in it and, hopefully, go to university to be engineers.²⁹

24 Government of South Australia, *Submission 43*, p. 8. The South Australian Government advised that it made this recommendation earlier at the Commonwealth States and Territories Advisory Council on Innovation.

25 The Warren Centre for Advanced Engineering, *Submission 27*, pp 2–3.

26 The Warren Centre for Advanced Engineering, *Submission 27*, p. 4.

27 The Warren Centre for Advanced Engineering, *Submission 27*, p. 6.

28 The Warren Centre for Advanced Engineering, *Submission 27*, p. 6.

29 Mr Dan Reeve, Capacity Chapter Member, Roads Australia, *Proof Committee Hansard*, 7 May 2012, p. 4.

3.22 The Australian Council of Engineering Deans believes that school mathematics and science curricula could be improved by finding connections between these disciplines and practical engineering applications.³⁰ Professor Roger Hadgraft and Professor David Beanland also agree with this recommendation.³¹ Given the observations in the *Health of Australian Science* report about student interest in practical, real life examples, this proposal may have some real merit. The committee however did not receive any evidence on this point from education departments.

3.23 The Warren Centre argues that government STEM policies should be particularly targeted at school children aged 12 to 15 and need to be supported by business and industry.³²

Committee view

3.24 The committee believes that the promotion of STEM subjects in primary and high school is important for the engineering profession, as well as for Australia as a nation. The committee understands that a number of measures to achieve higher STEM ability are being implemented across the states and territories, and that the Chief Scientist is tracking this trend and identifying areas where improvement can be made.³³ The committee hopes that these efforts to address the decline of STEM ability will be fruitful.

3.25 The committee believes that the examples outlined demonstrate the varied ways that industry, local governments and universities can engage school students in STEM subject matter, with an engineering focus. This engagement is important because increasing student participation in STEM subjects will increase the number of students who are eligible to study engineering at university and the number of students who decide to pursue an engineering related career through trade training.

3.26 However, as the bulk responsibility for primary and high school education rests with the states and territories, the committee believes that a multifaceted approach is needed to address the decline in STEM ability. The committee was particularly impressed with the STEM Skills Strategy developed by the South Australian government, and believes that this could be used as a model for other states and territories looking to improve the capacity of students to pursue careers requiring STEM skills.

3.27 The committee is also aware that the federal government can play a lead role in promoting STEM across Australia, particularly in light of the recently published findings by the Chief Scientist.

30 Australian Council of Engineering Deans, *Submission 65*, p. 1.

31 Emeritus Professor David Beanland and Professor Roger Hadgraft, *Proof Committee Hansard*, 7 May 2012, p. 28.

32 The Warren Centre for Advanced Engineering, *Submission 27*, p. 1.

33 Skills Australia, *Submission 80*, p. 18.

Recommendation 1

3.28 The committee recommends that the government seeks recommendations from the Chief Scientist about how it can best continue to support the development of science, technology, engineering and mathematics courses.

Recommendation 2

3.29 The committee recommends that the government works through the Council of Australian Governments to promote science, technology, engineering and maths ability in states and territories.

Vocational Education and Training

3.30 Engineering technicians and trade workers have obtained qualifications, generally, through VET.³⁴ The demand for trade engineers was discussed in Chapter 2. Skills Australia reports that VET engineering and related technologies commencements between 2005 and 2010 increased by 21 per cent overall, mostly at the Certificate III level.³⁵ During the same period:

- Advanced Diploma commencements decreased by 26 per cent
- Diploma commencements decreased by 12 per cent
- Certificate IV commencements increased by 79 per cent³⁶

3.31 During 2005 and 2010, VET engineering and related technologies total completions between 2005 and 2009 increased by 44 per cent. During the same period:

- Advanced Diploma completions decreased by 12 per cent
- Diploma completions decreased by 4 per cent
- Certificate IV completions increased by 83 per cent³⁷

Criticisms

3.32 The VET pathway did not receive the robust criticism that was directed at university teaching of engineering. This may be in part because the VET sector is targeted practical training, and because it often occurs within an apprenticeship framework, students are 'work ready' when they complete their qualifications.

3.33 The main criticisms about current VET education were that the pathways from VET to tertiary study were not at times clearly articulated and that employers often overlooked engineering technologists with a three year qualification, preferring

34 Some engineering technicians have completed a three year bachelor degree at university, nevertheless, that qualification is dealt with in this section.

35 Skills Australia, *Submission 80*, p. 10. (Citing data from the National Centre for Vocational Education Research). Skills Australia was superseded by the Australian Workforce and Productivity Agency on 1 July 2012.

36 Skills Australia, *Submission 80*, p. 10.

37 Skills Australia, *Submission 80*, p. 10.

instead to employ professional engineers with the four year bachelor degree.³⁸ Skills Australia believes that the qualification completion rates are 'unacceptably low'. If completion rates were improved then industry demand could more easily be met.³⁹

Improvements

3.34 As discussed earlier, the Government of South Australia has developed a detailed response to the engineering skills shortage in that state. One measure, to promote the use of apprentices, is a requirement that 15 per cent of total on-site labour hours in South Australian Government building and civil works must be worked by apprentices, trainees, Aboriginal people, local people with barriers to employment and through up skilling.⁴⁰

3.35 The Australian Council of Engineering Deans and the South Australian Government both called for attention to be given to improving the STEM ability of the workforce, noting that more support should be provided for mid-career entry to STEM occupations.⁴¹ Skills Australia also believes that the pathway from trade to tertiary qualification could be improved, for example, through improved career advisory services and the three year technologist degree provided by the Chisholm Institute, discussed below.⁴²

3.36 The Australian National Engineering Taskforce (ANET) has called for an increase in graduates from the three year para-professional degree. ANET argues that this would take the pressure off in-demand professional engineers. Further, these graduates could then move to professional status after a period of time.⁴³

3.37 The Chisholm Institute, a Melbourne based VET organisation that also offers a 3 year engineering technologist degree, submitted that the three year course can enable students with a weak mathematics background to enter engineering studies because of course requirements and emphasis.⁴⁴ The engineering technologist program focuses on 'technology and systems' whereas the four year professional program focuses on research and development and design.⁴⁵ The Australian Council of Engineering Deans suggested that the expansion of the Chisholm Institute into the three year degree could be replicated by other VET providers.⁴⁶

38 Chisholm Institute, *Submission 42*, p. 6; Skills Australia, *Submission 80*; Australian Council of Engineering Deans, *Submission 65*.

39 Skills Australia, *Submission 80*, p. 10.

40 Government of South Australia, *Submission 43*, p. 6. (On works worth more than \$5 million and at least 6 months in duration).

41 Australian Council of Engineering Deans, *Submission 65*, p. 1; Government of South Australia, *Submission 43*, p. 8.

42 Skills Australia, *Submission 80*, p. 2.

43 Australian National Engineering Taskforce, *Submission 73*, p. 18.

44 Chisholm Institute, *Submission 42*, p. 5.

45 Chisholm Institute, *Submission 42*, p. 6;

46 Australian Council of Engineering Deans, *Submission 65*, p. 9.

3.38 The Chisholm Institute recommends that, in accordance with the federal government's response to the Bradley review, the government funding of government supported places should be extended to all domestic students accepted into public higher education Engineering Technology programs accredited by the Tertiary Education Quality and Standards Agency. This will increase the number of students attracted to study the three year engineering technologist degree. The committee believes this idea has some merit, however, notes evidence from the Australian Council of Engineering Deans that many students who attain the three year qualification use it as a spring board to pursue further study to attain professional status.⁴⁷ Professor King noted that the three year qualification is very well suited, for example, to maintenance management, however employers are not aware of the capabilities of people with the three year qualification.⁴⁸

3.39 NORTH Link recommended that effective mentoring programs and support for apprentices, especially for small companies with limited human resource management capabilities, may improve retention rates. This is because early problems with the apprentice/employer relationship can be quickly resolved and any decision to leave employment will be carefully considered.⁴⁹ NORTH Link calls for a pilot mentoring program to be established.

Committee view

3.40 The committee notes that completion levels among VET students are too low, and that pathways from trade to tertiary skills are not as clearly articulated as they might be. The committee notes Skills Australia's observation that, if everyone who started a VET qualification in an engineering related trade completed it, the skills shortage would be diminished. However, having reached these conclusions, the committee does not consider that it is in a position to recommend a comprehensive suite of responses. Rather, the committee considers that the government should commission a study into the underlying causes of student attrition in VET, with a view to achieving better student outcomes.

3.41 The committee is also cognisant of the important role that para-professional engineers can have in the workforce, and supports the Chisholm Institute's recommendation that where a VET provider offers an accredited three year course this should also receive commonwealth support, in the way that students studying the same course at university are supported.

Recommendation 3

3.42 The committee recommends that the government requests the Australian Workforce and Productivity Agency, or a similar body, to investigate the reason why attrition rates for Vocational Education and Training courses in engineering

47 Professor John Beynon, President and Professor Robin King, Executive Officer, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 36.

48 Professor Robin King, Executive Officer, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 36.

49 NORTH Link, *Submission 81*, p. 5.

trades are so high. Based on the findings of this study, the committee recommends that the government work with Vocational Education and Training providers and the states and territories to improve completion rates.

Recommendation 4

3.43 The committee recommends that the government considers extending funding for government supported places to all domestic students accepted into public higher education Engineering Technology programs accredited by the Tertiary Education Quality and Standards Agency.

University

3.44 Universities offer three year engineering technologist degrees, and the much more popular four year engineering bachelor degree.⁵⁰ The committee heard from some witnesses that engineering courses do not produce 'work ready' graduates, and that university engineering programs are do not contain sufficient practical experience.

3.45 During 2001–2010 the overall domestic commencement figures in engineering have increased by 19.5 per cent, from 13 502 in 2001 to 16 131 in 2010.⁵¹ However, the committee notes that completions rose only 12.5 per cent for the same period.

*Commencements and completions for domestic engineering students, Bachelor degree and above, by gender*⁵²

Year	Commencements			Completions		
	Male	Female	Total	Male	Female	Total
2001	11 381	2 121	13 502	6 298	1 282	7 580
2002	11 186	2 052	13 238	6 000	1 208	7 208
2003	11 167	1 965	13 132	6 177	1 273	7 450
2004	11 008	1 910	12 918	6 304	1 312	7 616
2005	11 025	1 774	12 799	6 044	1 225	7 269
2006	11 090	1 923	13 013	6 357	1 249	7 606
2007	11 699	2 075	13 774	6 302	1 238	7 540
2008	11 998	2 226	14 224	6 645	1 282	7 927
2009	13 085	2 401	15 486	6 718	1 279	7 997
2010	13 649	2 482	16 131	7 107	1 414	8 521

50 Chisholm Institute is the only VET provider who offers the accredited 3 year engineering technologist degree.

51 Skills Australia, *Submission 80*, p. 7.

52 Skills Australia, *Submission 80*, p. 7. (Sourced from DEEWR higher education statistics, unpublished data from the Higher Education Data Cube. Note that commencement cannot be directly compared to completions for determination of retention and attrition).

3.46 In contrast, international student commencing numbers, have increased by 83.4 per cent since 2001, and international students completing university qualifications in engineering have increased by 126 per cent.

Commencements and completions for international engineering students, Bachelor degree and above, by gender⁵³

Year	Commencements			Completions		
	Male	Female	Total	Male	Female	Total
2001	4 400	881	5 281	2 269	518	2 787
2002	5 175	1 034	6 209	2 545	576	3 121
2003	6 472	1 208	7 680	3 306	712	4 018
2004	6 163	1 213	7 376	3 710	809	4 519
2005	5 900	1 257	7 157	4 224	939	5 163
2006	5 793	1 216	7 009	3 965	833	4 798
2007	6 342	1 393	7 735	3 922	867	4 789
2008	6 591	1 543	8 134	4 223	1 074	5 297
2009	7 996	1 790	9 786	4 471	1 018	5 489
2010	7 820	1 867	9 687	5 102	1 198	6 300

3.47 As indicated on the tables above, completion rates have also improved over time. However, there remain a high proportion of students who commence but do not complete an engineering degree. The data does not provide information about why students drop out of engineering courses. Indeed, some students may merely be transferring from one institution to another, and would be recorded as a dropout from one course, and a commencement at another.⁵⁴

3.48 The reasons why students drop out include lack of passion for engineering, poor academic results and because the course is not what the student expected.⁵⁵ Skills Australia believes that completion rates could be further improved if sufficient career advisory services were provided, while others have suggested that better articulated pathways from Vocation Education and Training qualifications to tertiary education would improve both commencement and completion rates.

3.49 Skills Australia has forecast that the total number of projected commencements in engineering courses could increase by 93.4 per cent by 2020.⁵⁶

53 Skills Australia, *Submission 80*, p. 7. (Sourced from DEEWR higher education statistics, unpublished data from the Higher Education Data Cube. Note that commencement cannot be directly compared to completions for determination of retention and attrition).

54 Skills Australia, *Submission 80*, p. 8.

55 Skills Australia, *Submission 80*, p. 9.

56 Skills Australia, *Submission 80*, p. 9.

Year	Commencements			Completions		
	Domestic	International	Total	Domestic	International	Total
2010	18 078	10 637	28 715	8 981	6 656	15 637
2015	28 450	13 636	42 086	13 972	6 784	20 757
2020	37 827	17 718	55 545	20 472	9 576	30 047

Source: Estimates derived from DEEWR (2011d), *Students, Selected Higher Education Statistics*.

a. Includes all domestic and international students in an engineering related field, at diploma level and above.

Criticism

3.50 The committee received evidence about weaknesses in university engineering courses. For example Professor Trevelyan argued that tertiary education did not prepare engineers, because it was focused on training students to 'write exam papers'.⁵⁷ As a result of weaknesses in the current university style of teaching engineering, higher numbers of students drop out and those that do graduate do not, in a general sense, exhibit the attributes that employers require.

3.51 The United Nations Educational, Scientific and Cultural Organisation commissioned academics Emeritus Professor David Beanland and Professor Roger Hadgraft to research and publish their findings on engineering education.⁵⁸ The professors argue that university engineering education must be transformed because the:

- attraction rate of students is very low;
- failure and drop-out rate over the course is approximately 40 per cent across Australia;
- attraction of female students into engineering remains low at approximately 12 per cent;
- graduates of engineering programs tend to strong on technical knowledge and deficient on the personal capabilities required to be effective engineers; and
- number of engineering graduates in Australia has been approximately half of the number required in each year of the last decade.

3.52 Professor Hadgraft and Professor Beanland argue that engineering programs should produce graduates who have the right capabilities and attributes to suit the profession. This can be achieved through project based learning and tailoring courses to ensure that students take an active role in learning rather than passively listening to lectures.⁵⁹ Professor Beanland observed that mathematical ability had also become an obstacle to students, even though it was becoming less important at a time when

57 Professor Trevelyan, *Proof Committee Hansard*, 27 March 2012, p. 4.

58 Emeritus Professor David Beanland and Professor Roger Hadgraft, *Submission 29*, p. 1. A manuscript has been prepared for publication by UNESCO and is forthcoming.

59 Emeritus Professor David Beanland and Professor Roger Hadgraft, *Proof Committee Hansard*, 7 May 2012, p. 23.

'simulation and computational methods' can be used to solve problems. Further, the relationship between employers and universities was described as 'very deficient' and a greater emphasis on workplace learning needed in engineering programs.⁶⁰

3.53 The Australian Council of Engineering Deans commissioned a study into engineering attrition rates in 2011. The study found that 65 to 70 per cent of students who commence a tertiary engineering program graduate. A five year study of retention is currently on foot.⁶¹

Improvements

Course structure

3.54 Submitters to the inquiry called for improvements to course material, increased practical experience and flexible learning. For example, some of the reforms proposed by Professors Beanland and Hadgraft include:

- Recognising that mathematical ability is not the only skill required by engineers. (As other skills such as communication, writing, project management and relationship management are also important).⁶²
- Accepting a wider range of students, and then streaming them after a two year general engineering course into the three year and four year degrees.⁶³
- Establishing a standard two year engineering program in universities across Australia⁶⁴
- Enabling students who have completed the two year general engineering qualification to graduate, and undertake a Diploma of Education. This ensures that teachers in high schools have a background in engineering and technology, not just maths and science⁶⁵
- Reforming engineering teaching so that there is more project based learning and practical, interactive assessment from first year.⁶⁶

3.55 During the Brisbane hearing Ms Megan Motto, Chief Executive of Consult Australia, called for more flexible delivery of university courses, noting that this

60 Emeritus Professor David Beanland, *Proof Committee Hansard*, 7 May 2012, p. 23.

61 Australian Council of Engineering Deans, *Submission 67*, p. 6.

62 Emeritus Professor David Beanland and Professor Roger Hadgraft, *Proof Committee Hansard*, 7 May 2012, pp 26–27.

63 Emeritus Professor David Beanland and Professor Roger Hadgraft, *Proof Committee Hansard*, 7 May 2012, pp 26–27.

64 Emeritus Professor David Beanland, *Proof Committee Hansard*, 7 May 2012, p. 28.

65 Emeritus Professor David Beanland, *Proof Committee Hansard*, 7 May 2012, p. 28.

66 Professor Roger Hadgraft, *Proof Committee Hansard*, 7 May 2012, pp 26–27.

would free up professionals to teach courses and also assist other people in full time employment who wanted to up-skill from a trade to a professional engineer.⁶⁷

3.56 Ms Megan Lilly, representing the Australian Industry Group (AiG), acknowledged that some of the criticisms about universities were valid. For example, a number of AiG's members send engineering graduates to TAFE for a few courses 'to give them the practical know-how'. However, Ms Lilly believes that the natural bias of universities towards academia could be overcome if engineering were taught 'in the context of the application of engineering, the employment of engineering and engagement with companies more broadly'.⁶⁸

3.57 The Australian Council of Engineering Deans (ACED) responded to criticisms about the quality of engineering education, arguing that a number of reforms had been implemented in the past five years and that the purpose of university education is not to produce 'work ready' graduates 'because the nature of engineering work is so diverse'.⁶⁹ The ACED also noted that engineering academics have a high work load and with reduced staff numbers many struggle to implement known improvements to engineering education.⁷⁰

3.58 In relation to the proposal that the program should introduce identical two year programs across all engineering faculties, the ACED argued that this would not help students who had already decided on the engineering field they wanted to pursue.⁷¹ The ACED also reported, in contrast to Professor Trevelyan's research, that engineering graduates were highly employable. For example, nearly 100 per cent of graduates with mining specialisations obtained work within 3 months, and electrical and mechanical engineering graduates employment rates were approached 'the high 80s and 90s' in percentage terms.⁷²

3.59 The ACED called for closer engagement between the engineering industry and universities in the areas of curriculum development, provision of case study and project development, structured training and scholarships.⁷³ These suggestions are discussed further in Chapter 5.

67 Ms Megan Motto, Chief Executive, Consult Australia, *Proof Committee Hansard*, 28 March 2012, p. 16

68 Ms Megan Lilly, Director Education and Training, Australian Industry Group, *Proof Committee Hansard*, 27 March 2012, p. 47.

69 Professor John Beynon, President, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 30.

70 Professor John Beynon, President, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 31.

71 Professor Robin King, Executive Officer, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 36.

72 Professor Robin King, Executive Officer, Australian Council of Engineering Deans, *Proof Committee Hansard*, 7 May 2012, p. 35. Professor King noted there had been a recent 'dip' in employment rates for computer engineering graduates.

73 Australian Council of Engineering Deans, *Submission 67*, p. 8.

3.60 The University of the Sunshine Coast provided a positive example of effective engineering education. The university obtained funding to build a new engineering building from the Education Infrastructure Fund. The facility will enable practical hands on learning for students and include a 'visualisation laboratory' that provides virtual reality modules to enable students to participate in 'engineering design and operational behaviours'.⁷⁴ The committee asked the university to respond to concerns raised by other submitters to the inquiry that university teaching is out of date and does not equip students for engineering work. Professor Mark Porter advised the committee that the program had been developed in consultation with industry, and that students were having no difficulty obtaining engineering work:

[I] think eight students going to graduate from our new program this April, all have jobs already. We have had phenomenal industry support and cooperation on the Sunshine Coast. They have been instrumental in helping to set up our degree, in making sure that it works according to what they want. In the consulting world, virtually every major international civil consultant now has an office on the Sunshine Coast. The majority of them are involved in supporting and advising us. Many have been giving us scholarships and many have been asking us for students for job positions, either part time while they are studying—in fact one of the local construction firms is offering, as a continuing offer, to send any of our third or fourth year students half time and they will give them a half-time job as well. They think fairly highly of what we are turning out. The way that we have developed it has been hand in glove with professional engineers and companies, and I think that is working.⁷⁵

3.61 Professor Porter added that the students in the engineering programs were all employed and that many students had obtained employment at the end of the third year of a four year degree.⁷⁶ The committee asked Professor Porter why his evidence contrasted so sharply with the evidence provided by Professor Trevelyan in Perth. Professor Porter considered it might be because the circumstances in the east and west of Australia varied. He also noted that at the University of the Sunshine Coast they try to counsel students, to assist them in determining whether engineering is the right career choice for them.⁷⁷

Completion

3.62 Skills Australia data, discussed in Chapter 5, reveals that while completion rates are improving, there are still a high proportion of students who commence but do not complete an engineering degree. The data does not provide information about why

74 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, p. 32.

75 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, pp 32–33.

76 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, p. 33.

77 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, p. 33.

students drop out of engineering courses, but Skills Australia believes that completion rates could be further improved if sufficient career advisory services were provided, while others have suggested that better articulated pathways from Vocation Education and Training qualifications to tertiary education would improve both commencement and completion rates.

From VET to tertiary qualifications

3.63 Changes also need to be made to assist workers with a trade background to transition to tertiary engineering qualifications. The committee heard that in Europe it is quite common for a person with a trade qualification to pursue an engineering degree, however this is less common in Australia. Mr Chris Fitzhardinge, Engineers Australia, explained to the committee:

A generation ago, to become an engineer you undertook an engineering degree. Now there are a variety of different pathways, including articulation from a diploma or a certificate qualification through into a degree qualification. In Europe it is quite common for people in the building trades to go on and do a degree in engineering. It is quite uncommon in Western Australia, typically because you lose salary going from being a tradesperson to being a newly qualified engineer. But, where engineering is highly respected within the community, there is strong articulation from the trades into engineering degrees. I think that is a pathway which needs to be encouraged—to take a basic interest or some skills and some background in engineering and then articulate it to becoming a professional engineer.⁷⁸

3.64 Some work has been done in this area, for example The University of the Sunshine Coast is working the Queensland Department of Education and Training and TAFE institutions to provide a seamless pathway from TAFE to university engineering courses.⁷⁹

Committee view

3.65 The committee considers that engineering teaching at university faculties can be improved. However, there are challenges. Professors Beanland and Hadgraft believe that engineering education can and should be radically changed at the university level. The committee notes that the Professors' UNESCO publication is forthcoming, and that the trial of a reformed program commenced at RMIT this year. The committee believes that it is prudent to await the results of the RMIT trial. The committee encourages the Australian Council of Engineering Deans and Skills Australia to track the Royal Melbourne Institute of Technology trial of 'reformed' engineering program, and consider whether the trial's findings have wider application.

3.66 Professor Trevelyan and others have called for more practical training of engineers after graduation. The ACED has stated that better engagement is needed

78 Mr Chris Fitzhardinge, former WA Division President, Engineers Australia, *Proof Committee Hansard*, 27 March 2012, p. 6.

79 Professor Mark Porter, Professor of Engineering, University of the Sunshine Coast, *Proof Committee Hansard*, 28 March 2012, p. 32.

between the engineering industry and universities in the areas of curriculum development, provision of case study and project development, structured training and scholarships.⁸⁰ The committee believes that industry committees advising universities need to be more involved in curriculum development on an ongoing basis, and not only when a new course is established. To achieve optimal results, the members of industry advisory committees should be selected on the basis of their direct interaction with graduates in their own organisation. If this is the case, industry representatives will be better able to provide practical, constructive feedback to universities.

Recommendation 5

3.67 The committee recommends that the industry committees advising universities take an active role in ensuring engineering courses are suited to industry requirements. To ensure their effectiveness, committees should include representatives with direct experience supervising and working with engineering graduates.

Conclusion

3.68 In this chapter the committee has highlighted the alarming decline in STEM ability, and provides some recommendations to address this trend. The VET and university pathways to engineering careers have been outlined, and the committee has recommended that completion rates in both streams need to be improved. The committee now turns to consider the impact of the skills shortage on the Australian economy and community.

80 Australian Council of Engineering Deans, *Submission 67*, p. 8.