Pathways from VET Awards to Engineering Degrees: a higher education perspective

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Executive Summary

This report provides an analysis of the provision and effectiveness of pathways to engineering degrees from award programs operated by the VET sector as a strategy to increasing engineering graduate numbers. The emphasis is on the pathways from VET Diplomas and Advanced Diplomas in engineering areas into Bachelor of Engineering degrees. The perspective is that of the engineering faculties and schools in the higher education sector.

VET Diplomas and Advanced Diplomas in engineering are competency-based programs aimed primarily at occupational outcomes. VET Advanced Diplomas in engineering may be accredited by the professional body (Engineers Australia) for entry to practice as Engineering Associates, although, to date, few VET providers have sought such accreditation. The provision of VET Diploma and Advanced Diplomas in many engineering disciplines is not uniform across the Australian states, with almost no provision of some disciplines outside capital cities. The number of graduates from Advanced Diploma programs in engineering is small, thereby restricting the size of the pool of students who are qualified to articulate into bachelors degrees.

All Australian universities accept students into engineering on the basis of complete or incomplete prior study in VET. Approximately six per cent of all Australian students commencing bachelors degrees in engineering gain admission on this basis. The proportion of such students varies widely between institutions and institutional groups: the largest participation rates are in dual-sector institutions and non-Go8 metropolitan universities.

The universities have developed systems to award credit for prior learning in VET awards. For engineering degrees, most deal with VET-qualified applicants on a case-by-case basis, because of the highly varied and modularised nature of the VET competency-based qualifications. The mismatches and gaps between the content of these qualifications and engineering degree programs are seen to be the biggest barrier to successful articulation. The degree graduation rate of VET-qualified students is, on average, significantly less than that of school-leavers.

Several universities have developed Associate Degrees, Foundation Programs, and higher education Diplomas as pathways into engineering degrees for students who do not meet the full requirements for direct entry into engineering degrees. These programs are curriculum-based and match their content to the requirements of the degrees to maximise credit. Associate Degrees may also be accredited by Engineers Australia as the entry qualifications for Engineers Associates. Some VET institutions are also developing Associate Degrees in engineering. The growth in these higher education awards may be reducing the numbers of enrolments in VET awards in engineering.

Fifteen recommendations are proposed to improve the effectiveness of articulation pathways. Some require the higher education engineering schools to develop closer and more effective collaboration with the VET sector and industry. Others, such as widening the scope of aptitude testing for degree admission, diagnostic testing of students followed by academic and other support, and improved timetabling for part-time students, are entirely within the scope of the engineering schools, and are likely to improve the retention and success rates for all students.

Given the skills shortages in all engineering occupations, the findings of the study strongly support the development of measures to increase the numbers of qualified Engineering Associates and Engineering Technologists, through development of programs for entry qualifications for these occupations offered by both the VET and higher education sectors.

Contents

Acronyms, Abbreviations and Glossary

APESMA	Association of Professional Engineers, Scientists and Managers, Australia
ACED	Australian Council of Engineering Deans
ALTC	Australian Learning & Teaching Council
ANET	Australian National Engineering Taskforce
AQF	Australian Qualifications Framework
ATAR	Australian Tertiary Admissions Rank
ATN	Australian Technology Network (of universities)
ATSE	Australian Academy of Technological Sciences and Engineering
BEng	Bachelor of Engineering
BEngTech	Bachelor of Engineering Technology
BoA	Basis of Admission
COAG	Council of Australian Governments
DEEWR	Department of Education, Employment and Workplace Relations (Commonwealth)
ERA	Excellence in Research Australia
FoE	Field of Education
Go8	Group of Eight (universities)
HEd	Higher Education (sector)
IEA	International Engineering Alliance
IRU	Innovative Research Universities (group)
ISC	Industry Skills Council
MEng	Master of Engineering
NCVER	National Centre for Vocational Education Research
OP	Overall Position (Queensland)
SES	Socio-economic status
STEM	science, technology, engineering and mathematics
TAC	Tertiary Admission Centre
TEQSA	Tertiary Education Quality and Standards Agency
TAFE	Technical and Further Education (institutes)
VET	Vocational Education and Training

The term ‘program’ is used for the course of study leading to an award. The term ‘course’ is normally used for a unit of study in the higher education sector. A typical BEng program has eight courses in each academic year.

The term ‘engineering school’ is used for the entity within each university that is responsible for the delivery of its engineering programs. Depending on university structure, this is may be a named ‘Faculty’, ‘School’, ‘Department’, or ‘Discipline’.

Acronyms for individual universities take their customary forms.

1 Introduction: addressing the shortage of engineering graduates

Australia faces its immediate future with fewer engineers[1] than it needs for its plans and expectations for physical infrastructure renewal and development, and its aspirations to be an innovative, knowledge-based and creative economy[2]. Both industrial and educational aspects of the engineering skills shortage have been charted in the recent ANET report, *Scoping Our Future* (ANET, 2010). Specific industrial sectors, including minerals and resources, and water, have undertaken specific studies of their future skills needs (Lowry et al, 2006, ICEWaRM, 2008). Such studies report skills shortages at all occupational levels, from engineering tradespeople to engineering paraprofessionals and professionals[3].

The prime teaching activity of the Australian universities' engineering schools is the education of four-year Bachelor of Engineering (BEng) graduates to enter practice as Professional Engineers. The university engineering schools also provide three-year Bachelor of Engineering Technology (BEngTech) programs and two-year Associate Degrees to prepare graduates for entry to the occupations of Engineering Technologists and Engineering Associates, respectively. VET sector providers also offer both VET and higher education qualifications at the Engineering Associate level, and prospectively, BEngTech programs.

The university engineering schools also undertake research and research training, and provide postgraduate masters degree coursework programs that fulfil one of three purposes:

- as an entry qualification for Professional Engineers after a (three-year) bachelors degree;
- as an advanced engineering specialisation for engineering graduates; or
- for development of (broader) professional skills for engineering practice.

The scale and status of Australian university engineering education was reviewed in 2007-8 in a study led by the Australian Council of Engineering Deans (ACED) in collaboration with Engineers Australia and the Academy of Technological Sciences & Engineering (ATSE), and funded by the Australian Learning & Teaching Council (ALTC). The principal findings and recommendations of that review (King, 2008) were derived from more than 60 consultative forums of employers, members of the profession, academics and students. Actions on most of the six broad recommendations have been progressed in further studies and activities within engineering faculties and schools. Recommendation 6 urged action to address engineer shortages by further development of educational pathways and support, and increasing the participation of under-represented groups.

The evidence from the review and subsequent work indicates that the quality of Australian engineering degrees is being maintained to international standards, and can be further improved by specific actions. Improving enrolment trends into engineering degrees since 2005, and increasing graduation rates from them, give the higher education engineering providers some reassurance that the attainment of a professional engineering degree remains a desirable and attainable goal for Australian school-leavers, including the most academically talented.

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[1] The word 'engineer', without further elaboration, is used inclusively to cover qualified professional engineers, engineering technologists and engineering associates (technicians).

[2] Several other industrialised nations, including USA and UK, also report engineer shortages in general, and in specific industry sectors.

[3] Many professionals in 'construction', such as quantity surveyors and project managers have qualifications that are accredited by non-engineering professional bodies.

Acceptances by the universities into engineering have made up around seven per cent[4] of all student acceptances into undergraduate programs in each of the years 2007-9. As the absolute number of domestic engineering graduates is likely to continue to remain below that required to satisfy broad employer demand[5], the universities' engineering providers have continued to focus considerable attention and investment on student recruitment and retention.

The universities' engineering schools, individually and collectively, are using several approaches to increase the numbers of engineering professionals at the three defined occupational levels. As service providers, driven primarily by student demand, the engineering schools' main focus (like this report) is on increasing the numbers and quality of graduates qualified to enter professional engineering, primarily via Bachelor of Engineering degrees. The emphasis in this report is on increasing the numbers of **Australians** in these and equivalent programs. Whilst Australian universities have been very successful in recruiting international students (see Section 2.1), most overseas **bachelors** degree graduates expect to take up employment in their home countries[6], although they may be predisposed and well prepared to join the Australian engineering workforce at a later time.

1.1 Increasing the numbers of Australian bachelors graduates in engineering

There are several possible approaches to building the number of bachelors degree graduates in engineering. Increasing the number of **commencing** students is the first challenge; the second is to ensure that as many students as possible continue in their engineering studies and **graduate** when they attain the required standard.

A recently completed collaborative project, led by ACED (and administered at the University of Technology, Sydney) with principal funding by the ALTC (Godfrey & King, 2011) addresses both of these issues.

On graduation rates, detailed cohort studies have revealed that overall, engineering graduation rates are higher than reported in the 2007-8 review (King, 2008), and are on average around 65 per cent[7], with institutional variation in the range 40–75 per cent. This revised overall graduation rate figure takes into account student transfers between universities. Lower graduation rates are associated with institutions from which able students transfer to more prestigious institutions, and which have higher numbers of mature and part-time students. The 2011 report identifies a number of strategies for improving student retention in engineering.

The study also took up Recommendation 6 of the 2007-8 review by investigating increasing the supply of professional engineers by developing a range of pathways and increasing the participation of women and Indigenous students. Much of the material provided here is

[4] The Australian participation rate in university engineering education in higher education is similar to those in UK and USA but less than the rates found in Japan, Korea, China and India.

[5] The nature of employer demand for engineers is the subject of a separate ANET project. Much of the public professional commentary refers to the shortage of **experienced** engineers; an increase in graduate numbers can address this only in the longer term, and requires graduates to have good opportunities and experiences in initial graduate employment.

[6] This is especially so for international bachelors degree students who study in their home countries in off-shore campuses. At least five engineering schools operate accredited bachelors degree programs offshore in Singapore, Malaysia, Hong Kong, Vietnam, and UAE. International masters degree students are more likely to be seeking Australian residency.

[7] This is a higher figure than most discipline areas in Australian universities, other than medicine and some of the more prestigious health areas.

developed from the findings in that study. What is not discussed further here is the growth of pathways for graduates of other disciplines (such as science) to take a suitably designed "conversion" masters degree qualification for entry to professional engineering (Godfrey & King, 2011: 158). These programs are also suitable for overseas graduates with engineering qualifications that are not recognised by Engineers Australia as meeting the required standard to enter practice.

There are several other strategies for increasing the number of commencing students in bachelor degrees in engineering. These are outlined in the following paragraphs.

1. Growing engineering's share of the total commencing student undergraduate students

   In recent years, this proportion has been increasing slowly, but not sufficiently to make major inroads into the apparent skills gap. The proportion of domestic applicants who accepted offers of places in undergraduate degrees in engineering via the state tertiary admissions centres rose from about 6 per cent in 2006 to 7.5 per cent in 2009 (Godfrey and King, 2011:18). The growth engineering discipline is civil engineering. It is interesting to note that the overall increase (of student numbers) in engineering roughly balances the decline in enrolments in Information Technology programs since 2005. Further significant increases in engineering enrolments would have to draw on school leavers who might otherwise choose science, design and architecture, business, or health.

   To counter the apparently enduring negative image that degree study in engineering has, engineering schools and the profession at large undertake a very wide range of outreach activities in primary and secondary schools. Many of these activities focus on increasing participation in higher levels of school mathematics and science subjects. The relatively weak positions of "design" and "technology" within school curricula may also contribute to low engagement with notions of engineering. There is, nevertheless, some evidence for the value of strong activities in these areas, especially in secondary schools in low SES localities, for encouraging students across of wide range of ability, to pursue subsequent tertiary engineering studies (Thompson, 2010).

2. Increase the percentages of female and Indigenous students in undergraduate engineering programs

   In 2009 women constituted nearly 60 per cent of all bachelors degree graduations by Australians, but only 14.9 per cent of engineering graduates. Increasing the participation rate of women in engineering to that of their overall participation rate in university higher education would clearly make a major contribution to addressing the skills shortage. As the trends discussed in Section 2.1 show, Australian female commencements in engineering have declined since peaking in 2000, and remain below 15 per cent. The recent study (Godfrey & King, 2011:177-191) examines some of the issues around the persistently low levels of female participation in education, and in the engineering workforce. The report also discusses how greater participation of Indigenous students might be achieved; noting the broad community value of having what would always be a small number of Indigenous engineers (Godfrey & King, 2011:192-202).

3. Increase the number and use of entry pathways such as Foundation Programs that enable entry by students who are ineligible for standard entry

   Universities have operated a range of 'bridging' programs to enable such students to enter degree programs for many years. Some of these have now been formalised into Foundation Programs for both Australian and international students. For engineering, the recent study (Godfrey & King, 2011:148) discussed how these have been developed at a number of universities, and that their content focuses on mathematics and science and study skills to bring individuals without the normal prerequisite secondary school knowledge in these subjects to the levels required to commence first-year degree studies. A related development is the use of aptitude tests to capture prospective students with interests in studying engineering but without the required prerequisites to enter engineering and provide bridging courses to enable them to fill any gaps prior to commencing their degree.

4. Increase the numbers of graduates from Associate Degree and Bachelor of Engineering Technology programs to articulate into the Bachelor of Engineering program.

   As discussed further in Section 2.2, there has been considerable growth of Associate Degree programs in engineering in recent years. This qualification may serve both the role of providing entry to the recognised occupation of Engineering Associate (Section 1.3) and that of a pathway to bachelor degree studies. The entry requirements for Associate Degrees tend to be rather more diverse than those for bachelors degrees, and it appears that most students taking Associate Degrees aspire to use them as a pathway to a professional engineering qualification (Dowling 2010b). The three-year Bachelor of Engineering Technology degree may also be used as a step towards a professional engineering qualification by many of the relatively small numbers of students who are enrolled in them.

5. Increase the number of graduates from VET Diploma and Advanced Diploma programs to progress to Bachelor of Engineering programs

   The fifth strategy for increasing the number of professional engineering graduates is to successfully transition more graduates with VET qualifications into degree programs. The most relevant qualifications are Diplomas and Advanced Diplomas in engineering areas. Discussing such articulation generally, Wheelahan and her colleagues report that the applicants with VET Diplomas and Advanced Diplomas are offered places in university programs at a similar rate to other categories of applicants, such as school leavers, but these applicants are under-represented at elite universities (Wheelahan et al, 2009).

   The data presented here shows that this pathway is under-represented in engineering degrees. While most articulating candidates into engineering degrees are likely to have studied at least at the VET Diploma level, there are also some experienced members of the workforce with engineering trades qualifications (Certificate III) who may articulate into degrees via Associate Degrees, as discussed later in this report.

Wheelahan et al. (2009) has discussed strategies such as these as aiming to *deepen* participation in higher education generally, by increasing student numbers from social groups already well represented, and *widen* participation by growing student numbers from under-represented social groups. Addressing engineering, the data and commentary in the report builds on the present authors' findings and analysis in previous studies (Godfrey & King, 2011, Dowling, 2010a, 2010b). As such, this is the first known attempt to present a national picture of articulation between VET and higher education qualifications in engineering. The data is presented against national educational and professional settings described below.

1.2 Commonwealth government initiatives

Australia's degrees that lead to professional engineering qualifications are all provided by public universities. Although they operate largely autonomously, and self-accredit the awards they provide, the universities work within a complex and changing regulatory framework. Their research outcomes are under scrutiny after publication of the Excellence in Research Australia findings (ARC, 2011), with a review of the ERA indicators in progress. The universities will soon be regulated by the new Tertiary Education Quality Standards Agency (TEQSA). From 2012, caps will be removed from undergraduate admission numbers, as the system becomes more strongly student-demand driven. The funding arrangements for Australian student places in undergraduate and postgraduate coursework programs are currently under review (DEEWR, 2010c). Although all of these issues and bodies will impact on the future provision and quality of engineering education programs, further discussion of them is beyond the scope of this report.

Two Commonwealth government initiatives are, however, directly relevant to this report. The first stems from the national review of higher education (Bradley et al, 2009). During 2010, the Australian government adopted the recommendations of this review in setting future ***attainment*** and ***equity*** targets for future bachelors degree graduates:

- 40 per cent of all 25 to 34 year-olds to attain a qualification at bachelor degree level or above by 2025: for engineering this includes 3-year and 4-year degrees;
- 20 per cent of all higher education undergraduate enrolments to be students of low socio-economic status[8] by 2020.

The equity target has increased the universities' focus on recruiting undergraduate students with VET qualifications, as such qualifications are held proportionately by more low SES students than those currently gaining degrees. However, as noted earlier, there is evidence (Wheelahan, et al., 2009) that this is not so for students who articulate from VET programs, (the target of Strategy 5 referred to above) as the socio-economic profile of this group is, overall, similar to that of existing university students. There is, however, at least in some universities, evidence that the participation rate by low SES students is already higher in engineering degrees than in other professional areas, such as medicine and law.

The overall attainment target also requires universities to ensure that such equity students actually ***graduate***, specifically from bachelors degrees. It would appear to be in their interests for university engineering faculties and schools to maximise their contributions to both of these targets, as well as contributing to national growth targets for educational outcomes in general and engineering in particular. The educational mechanism for making such contributions is to develop and operate clear pathways for VET qualified students to progress into engineering degrees, with appropriate credit for their previous studies, and provide appropriate levels of support to enable them to be as successful in their studies as students from other cohorts, and graduate from their program.

The second national initiative of relevance is the revision of the Australian Qualifications Framework (AQF). Approved by the Council of Australian Governments (COAG) in March 2011, the revised AQF sets out a ten level structure for recognised qualifications, spanning both

[8] The Commonwealth currently defines a student's SES status via the Australian Bureau of Statistics (ABS) Socio-Economic Indexes for Areas (SEIFA) Index of Education and Occupation (IEO) to rank postcodes. The postcodes that comprise the bottom 25% of the population aged between 15 to 64 years at the date of the latest census, based on this ranking, are considered low SES postcodes. Students who have home locations in these low SES postcodes are counted as 'low SES' students. The status for each postcode is calculated from a combination of indicators. Different measures are used in the VET sector which makes comparisons between the sectors difficult. There is currently a study on developing an improved low SES measure.

the higher education and VET sectors (AQF, 2010). Each level is described by broad learning outcomes, and each qualification is expected to have clear occupational outcomes and educational pathways. AQF levels relevant to this report are shown in Table 1.

1.3 Accredited qualifications for recognised engineering occupations

Australian engineering qualifications are formalised against occupational definitions and the membership structure of the national professional accrediting body, Engineers Australia. The latter recognises three occupations and categories of membership (see Table 1). Engineers Australia operates program accreditation systems for each qualification level, and maintains lists of the currently accredited programs for each occupational category (Engineers Australia, 2011). Appendix 1 reproduces Engineers Australia's descriptions of the role of each of the three occupational categories. Recently revised Stage 1 Competency Standards. (Engineers Australia, 2011, Godfrey & King, 2011: 89-131) set the outcome expectations for graduates from accredited programs in three domains: knowledge; engineering application; and personal and professional skills and attributes. The accreditation process focuses on these outcomes, and the resources and systems deployed by provider institutions to ensure their quality and maintenance.

Engineers Australia is a signatory to well-established international agreements (accords) operated under the banner of the International Engineering Alliance. The Accords formalise mutual recognition of other nations' accreditation processes that deliver award programs to agreed graduate attributes and subsequent professional competencies for each occupational category (IEA, 2009). Engineers Australia was a foundation signatory to the Washington Accord (1989), became a full signatory to the Sydney Accord in 2008, and has applied for membership of the Dublin Accord in 2011.

Table 1 Professionally accredited engineering qualifications

engineering occupation (IEA Educational Accord)	accredited award qualification (generic titles)	minimum program duration post-secondary school cert. (full-time academic years)	AQF Level
Engineering Associate*	Advanced Diploma (VET)	2	6
(Dublin Accord)	Associate Degree (HEd)	2	6
Engineering Technologist (Sydney Accord)	BEngTech	3	7
Professional Engineer	BEng	4	7
(Washington Accord)	BEng (Honours)	4	8
	BEng, Dip.Ind.Prac.	5	7 or 8
	MEng (integrated or graduate entry)	5	9

* Internationally, this occupation is normally known as Engineering Technician. The Engineering Associate is frequently also described as a 'paraprofessional'.

Table 1 shows where the three qualifications are placed on the revised Australian Qualifications Framework. The complexity of the relationships between qualifications and engineering careers in this simple table shows the reasons why prospective students, parents, careers advisors, and even employers, may find career planning in this field so confusing. The table also shows that there is direct correspondence between AQF Levels 6 and 7 and the qualifications for Engineering Associate and Engineering Technologist, respectively. Qualifications for entry to the Professional Engineer career are at Levels 7, 8 and 9.

The Engineering Associate occupation has two qualification routes: the Advanced Diploma and the Associate Degree. Advanced Diplomas in engineering are provided, almost without exception, as competency-based training packages, by public Technical and Further Education (TAFE) institutes in the VET sector. Associate Degrees in Engineering are classified as higher education awards and are invariably provided as curriculum-based programs. Most Associate Degrees in engineering are currently provided by universities, but an increasing number of VET institutions are offering, or considering offering this qualification. Engineers Australia has developed accreditation management systems for both VET and higher education qualifications for the Engineering Associate occupation.

Whilst the AQF does not differentiate between three-year and (non-Honours) four-year undergraduate degree qualifications, there are clear distinctions in their outcomes and value for engineering careers. The Engineering Technologist occupation has one qualification, a three-year accredited Bachelor of Engineering Technology. Currently all of the accredited Bachelor of Engineering Technology programs are provided by universities. However, in 2011 a BEngTech is being offered for the first time by a VET institution, the Chisholm Institute in Victoria. This program has strong support from the local manufacturing industries and has been provisionally accredited by Engineers Australia, pending the first graduating cohort. It is anticipated that other VET institutions will follow this trend.

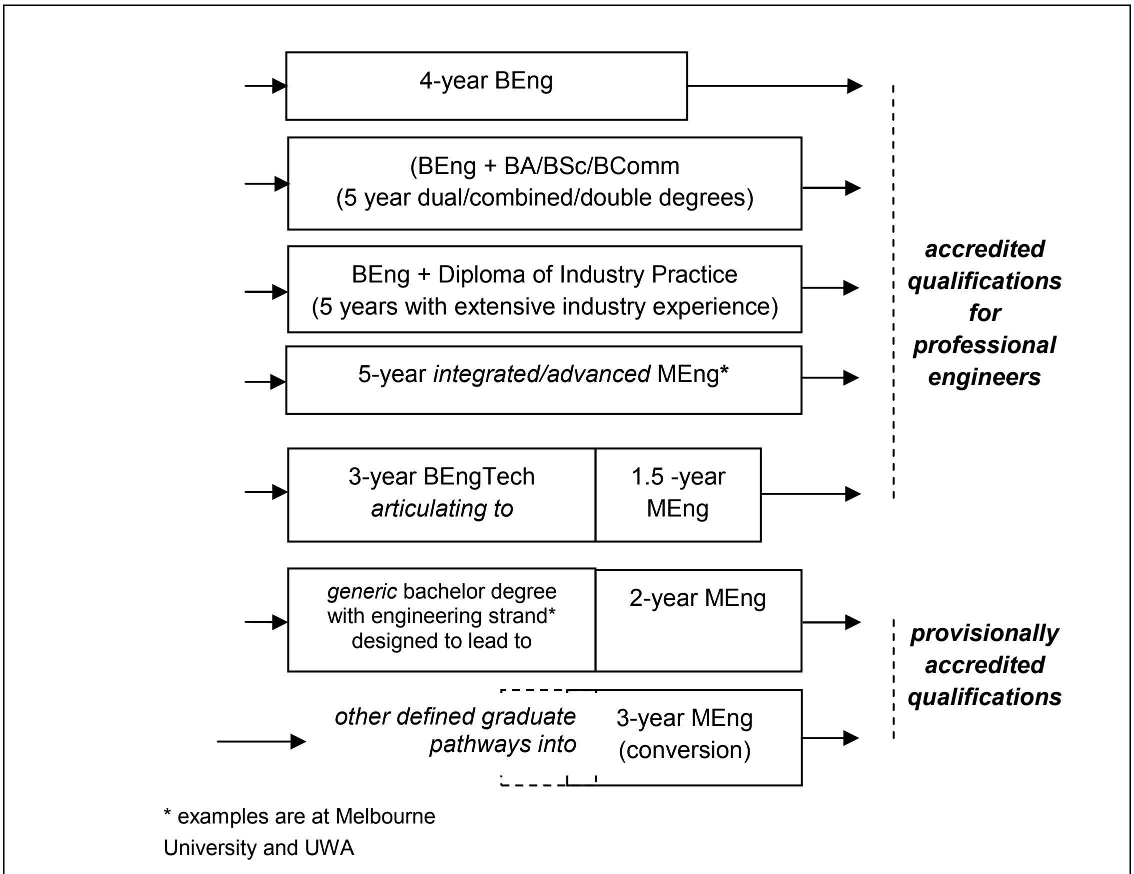

Figure 1 Degree program structures that satisfy Engineers Australia's accreditation requirements for entry to the occupation of Professional Engineer. (Award titles differ between institutions. Durations are full-time academic years.)

Table 1 shows that the Professional Engineer occupation has four qualification routes: a Bachelor of Engineering; a Bachelor of Engineering with Honours; a range of combined degrees that includes a Bachelor of Engineering; and a range of masters degree programs. These routes to accredited professional engineering qualifications are depicted in Figure 1.

The basic four-year Bachelor of Engineering qualification for entry to practice as a Professional Engineer was prescribed by Engineers Australia from 1980. This award is at Level 7 of the AQF, or at Level 8 if the degree is awarded "with Honours" based on merit. Many engineering students undertake double/combined/dual degrees in which the BEng meets the accreditation standard, and a small number of institutions offer extended programs that include substantial work experience for which a separate qualification may be awarded.

Figure 1 also shows accredited award patterns that have a Master of Engineering as the professional engineering qualification, and has recently issued guidelines (Engineers Australia, 2010) to assist providers to develop stand-alone 'graduate entry' MEng awards. These are, in essence, 3-year graduate entry programs that include up to one year of preliminary coursework and provision for credit for the qualifying bachelors degree. The emergence of these graduate pathways to increase the number of engineers is discussed in more detail in the recently completed project (Godfrey & King, 2011: 158).

Although professional accreditation is voluntary, all Australia's universities that operate BEng (or equivalent) programs seek to have these programs accredited. By contrast, some institutions do not seek accreditation for their BEngTech and/or Associate Degree programs that are intended primarily as 'pathway' awards. The lack of consistency in program titles and outcomes is potentially confusing for prospective students, students and employers.

1.4 Articulation pathways into engineering degrees from VET awards

The focus of this study is on VET pathways to BEng and BEngTech degrees. The study thus focuses on the interfaces between the two tertiary education sectors. To set the context, Section 2 provides national data on the student numbers in the 'targeted' bachelors degree awards, and also discusses the growth of associate degrees in engineering, and the basis of admission of students commencing them. As implied earlier, the majority of Australian (and international) students who enter bachelors degree programs do so directly from secondary level studies, on the basis of their academic attainment as encapsulated in their secondary school certificate, and in their Australian Tertiary Admission Rank (ATAR). School-leavers are **not** the focus of this report.

The focus here is principally on the pathways taken by students who articulate into engineering degrees (BEngTech or BEng) from engineering studies in the VET sector, specifically from Advanced Diplomas and Associate Degrees in Engineering (AQF Level 6), and to a lesser extent, Diplomas (AQF Level 5). Figure 2 illustrates the model, and also shows that a trade qualification can be a route into an Associate Degree[9].

The broad vertical arrows in Figure 2 indicate that students may transfer from a program on or before its completion, as in the case of transfer from the second year of BEngTech study into the third year of a BEng where these programs up to the point of transfer have identical or

[9] Whilst there is, quite properly, considerable national, state and employer interest and emphasis on skills shortages in engineering-related trades, it is important to realise that pathways into engineering degrees for engineering tradespeople (electricians and plumbers, for example, have AQF Level 3 qualifications) would normally require them to take additional study (such as a university-based Foundation Program) to bridge gaps in mathematics and science, as well as develop university study skills. Exceptionally, the Associate Degree provides an alternative route into degree studies – see Section 2.2

almost identical content. Some institutions may allow students to transfer when it suits them, once they are academically eligible to do so. Transfer can be within the same university or to another provider. The point of entry, and corresponding academic credit, is determined by the requirements of the program and university into which the student is transferring, and their academic progress. Issues of credit transfer are discussed in Section 3.

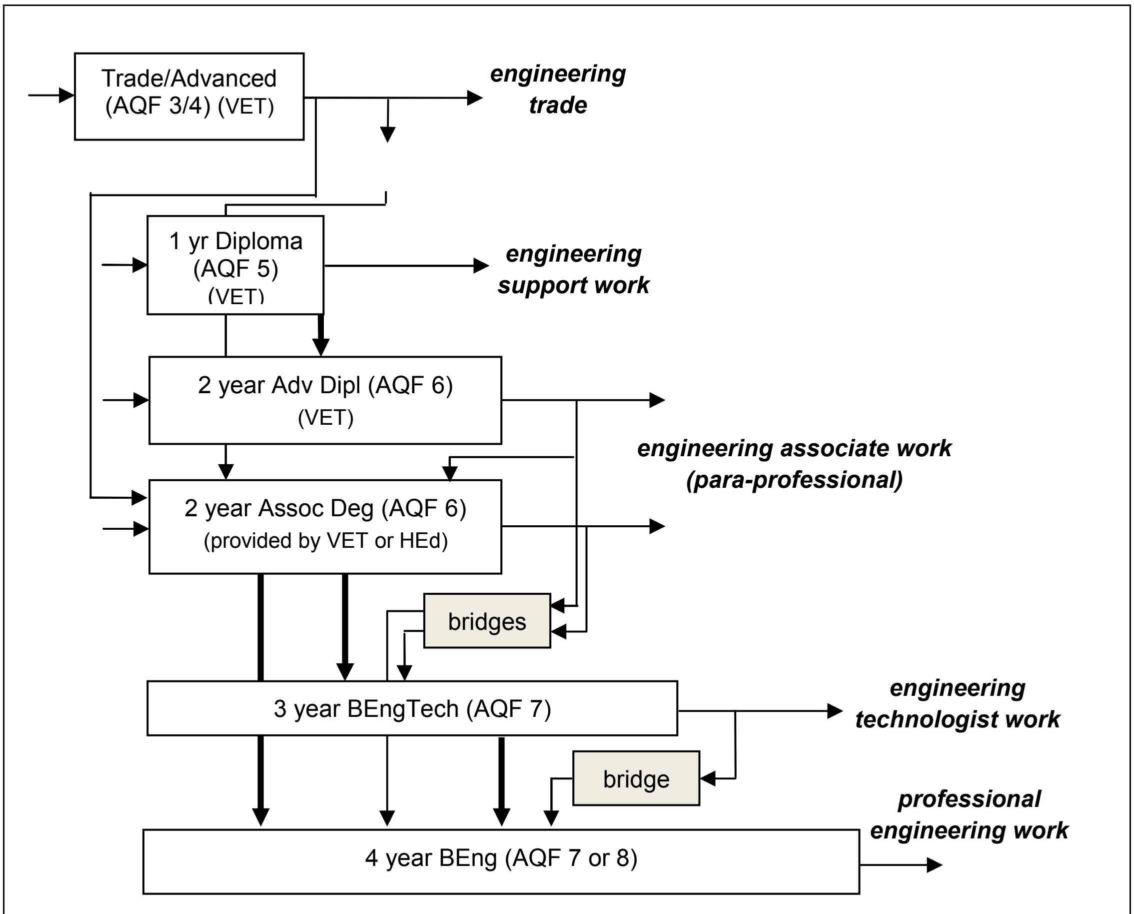

Figure 2 Pathways from VET engineering qualifications at AQF Levels 5 and 6 to HEd programs. (Not all possible transfer paths are shown, and the bridging requirements and points of articulation vary between programs and for individual students)

Figure 2 shows that the articulation pathways[10] from completed awards to the next or higher level are via 'bridges'. These represent additional study necessary for articulating graduates to enter at a particular point (with credit) into the higher level award. For example, Advanced Diploma holders transferring to a 4-year BEng program would typically need to take additional mathematics before they could fall into step with the program at the point of entry. The educational bridges arise fundamentally because the lower level qualification cannot be a simple subset of the higher level qualification if it is intended to meet Engineers Australia's accreditation requirements for entry to the relevant occupation. For example, an advanced diploma may contain greater specialist expertise (eg in the use of CAD design tools) than the

[10] This articulated model for progression through engineering awards has been in operation for some time, and was described formally more than two decades ago (Lloyd, et al.,1989).

corresponding degree, but much less mathematics and fundamental science. The **articulation with credit and bridging** concept is consistent with having awards meet both employment and educational pathway outcomes.

Bridging programs are more important for VET graduates who want to study full-time on-campus at a university so that they can fit into the standard enrolment pattern and timetables. These types of bridging programs are normally formalised by an agreement between the relevant institutions. Bridging programs are less important for students who study part-time, particularly by distance education. These students can follow their own pathways to cover early year material and construct their own schedules for later year subjects.

1.5 The research questions, methodology and report outline

The present study is intended to inform the notion that there is a significant proportion of students in VET engineering programs who have both aspiration and ability to articulate into, and graduate from, engineering degrees, either at BEngTech or BEng levels. We seek to answer the following questions, from a higher education perspective:

- **(i) What VET and HEd engineering programs are currently offered at AQF level 6 and what are the graduation patterns in those programs?**
- **(ii) What are the characteristics and career aspirations of the students in those programs, particularly those on articulation tracks?**
- **(iii) What pathways exist between which institutions; how many students are currently taking these pathways?**
- **(iv) What are the examples of successful practice in operating pathways; what are the barriers to articulating students succeeding?**
- **(v) How can pathways be improved; what measures need to be taken to increase their effectiveness?**

The effectiveness of VET engineering award programs for fulfilling their primary purpose as qualifications to satisfy occupational needs is a very important topic which is not covered here. There would be value in undertaking such a study in order to establish clearer understanding of the skills shortages in para-professional and engineering support occupations, and the demand patterns and constraints on the provision of such qualifications.

Sections 2 and 3 examine the first question by firstly discussing the national provision of engineering degrees into which VET students may articulate, and secondly by summarising the provision of relevant VET awards in engineering. The latter material draws on previous work by Dowling (2010a). Student data and information about programs has been obtained from the government's Higher Educational Statistics branch, the National Council for Vocational Education Research (NCVER), and institutions' websites. The data shows that the annual number of VET students qualifying with Advanced Diplomas in engineering disciplines is approximately one quarter of the annual number of BEng graduates, imposing a clear constraint on the number of VET graduates 'potentially available' for articulation. The second question is discussed in Section 4 which draws on the findings of a study undertaken by Dowling (2010b).

Section 4 also answers question (iii) by discussing the mechanisms of articulation, the award of credit, and bridging, and the likelihood of success of degree graduation. In identifying barriers and examples of successful practice, this section expands on the findings of the recent study that involved nine engineering faculties (Godfrey & King, 2011:158-164), to provide a more complete national picture of national provision of pathways. The most commonly identified barriers stem from the dichotomy between the competency-based training packages operated by the VET system and curriculum-based education provided by the universities' engineering faculties and in the HE qualifications offered by VET institutions.

Section 5 discusses question (iv) and (v) by examining measures that the universities and VET institutions can take to improve the performance of pathways. As with the identification of barriers, the analysis and recommendations are developed from the recent ALTC study, and are informed by the involvement of a larger number of universities in a greater number of locations. This section concludes with a commentary on broader policy issues that would need to be addressed to achieve greater value from these pathways.

To conclude this introduction we observe that all stakeholders are positive with respect to the importance of articulation in engineering. Students and employees see the articulation pathways as opportunities to gain professional level qualifications and career advancement. The professional body, Engineers Australia, supports the provision of such pathways and the opportunities they present to its members, and to increase engineering numbers. For many universities, the pathways offer potential ways of further increasing the diversity of their student body, where the lower level awards have higher proportions of students from lower socio-economic backgrounds, than the direct school leaver entrants into BEng programs.

This review and analysis of the current provision of articulation pathways into engineering degree programs, from the perspective of the higher education providers, thus provides stakeholders in the tertiary education sector, the profession, and industry with insights on increasing the effectiveness of the pathways.

2 Australia's undergraduate programs in engineering: a summary

Since this study is concerned with articulation pathways into bachelors degrees in engineering it is necessary to briefly review the broad characteristics of these degree programs, as they provide quite stable **targets** for articulation pathways.

The 2007-8 review of engineering education (King, 2008) listed 33 university engineering program providers, identifying for each, their engineering disciplines (areas), their undergraduate enrolment size (small medium, large), and whether or not they provided BEngTech and Associate Degree qualifications. These data have been updated in Appendix 3, and include three more universities that are now offering engineering degrees. This data is summarised in Table 2.

The 2008 review report included aggregated statistical data on student commencements, total enrolments, and graduations for all program levels (from 'enabling' to doctorate programs) for 1996-2006, or the latest available validated year's data. For each year since 2008, ACED has collected similar data and has extended the datasets to cover student retention and success data, and the basis of admission into undergraduate programs. The human outcome – graduates – of Australia's engineering higher education system is enumerated by the award completions data in Appendix 4. Specific data relevant to pathways are provided in the following sections.

A major component of the recent project was the issue of ***attrition*** from undergraduate engineering programs (Godfrey & King, 2011: 1-88). To provide stakeholders (the universities, profession, industry and government) with insights into institutional differences, but without identifying individual institutions, data was presented by the university groupings as in Table 2, updated here with the new providers. This practice is also used in the present report, as it reveals adequately the substantial diversity in the enrolment profiles of the university engineering providers, with respect to the relative importance of pathways for students with VET qualifications. The groups used are those defined in a national report on tertiary admission (DEEWR, 2010a). The "Technology" group includes the five universities in the Australian Technology Network (ATN).

Table 2 University groups used in this study (defined in DEEWR, 2010b)

university group	universities with fully accredited engineering programs
Go8 (8)	Adelaide, ANU, Melbourne, Monash, New South Wales (including UNSW@ADFA), Sydney, Queensland and Western Australia,
IRU (7)	Charles Darwin, James Cook, Griffith, Newcastle, La Trobe, Flinders and Murdoch
Technology (6)	Curtin, QUT, RMIT, Swinburne, UniSA, UTS
Metropolitan (9)	Canberra, Deakin, Edith Cowan, Macquarie, Victoria, Wollongong, Western Sydney, Tasmania (including the Australian Maritime College), Sunshine Coast
Regional (4)	Ballarat, CQUniversity, New England, Southern Queensland,

The following sections provide summary program information and relevant student data for the three undergraduate programs into which VET students may articulate: Associate Degrees, BEngTech degrees and BEng degrees, as depicted in Figure 2.

2.1 Bachelors degrees in engineering: typical structure and student data

A four-year Bachelor of Engineering degree accredited by Engineers Australia is the standard qualification to begin Professional Engineering practice in Australia. Since 2006 about 5,500 – 6,000 domestic students have graduated annually from accredited BEng programs, alongside a rising number of international BEng graduates (about 2,500 in 2008 and 2009).

A three-year Bachelor of Engineering Technology degree accredited by Engineers Australia is the intended entry-level qualification for the occupation of Engineering Technologist. Following its introduction in the early 1990's there was a steady increase in programs and student numbers until about 2005 when both student numbers and the number of programs began to decline. The Australian three-year engineering programs have not attracted as many students as their equivalents in other countries such as the Canada, Ireland, New Zealand, and the UK. In Australia, where it is offered, the three-year program is valued by students as much for its role as a pathway to a BEng program, as it is for its occupation and employment outcomes. The evidence collected in the 2007-8 review and subsequently, has revealed that many employers are unsure of where this occupational category fits into their organisation, or their industrial award structure. Approximately 600 domestic students graduate from BEngTech programs each year, together with 450 international students. The growth potential for these programs to address engineering skills shortages deserves much more attention than it has had to date.

Irrespective of differences in pedagogical approach to meeting the graduate outcome standard for accreditation, the four-year BEng degree programs (and their longer duration equivalents) operated by Australian universities have a fairly common structure as presented in Table 3. Each engineering discipline[11] (chemical, civil, electrical, mechanical, etc) has substantially similar core content, especially during the first three program years, after which students can specialise further. In fact, many engineering faculties operate fully common (or largely common) first-year curricula across all engineering disciplines. Importantly, all BEng programs contain substantial research and/or design-based project work in their final year, and have a requirement for students to gain industry experience, usually out of semester time.

Table 3 The sequence of courses in a typical (generic) BEng program

Semester 1	Mathematics 1	Physical Science 1	Computing	Intro to Engineering
Semester 2	Mathematics 2	Materials Science	Engineering Science 1	Intro to Eng. Discipline.
Semester 3	Mathematics 3	Physical Science 2	Engineering Science 2	Engineering Design 1
Semester 4	Engineering Science 3	Engineering Science 4	Engin'g Application 1	free elective
Semester 5	Engin'g Application 2	Engin'g Application 3	Intro to Bus. Practice	Engineering Design 2
Semester 6	Intro to Specialisation 1	Intro to Specialisation 2	free elective	Eng Proj Management
Semester 7	Engin'g Application 4	Specialisation core 1	Specialisation core 2	Project – part A
Semester 8	Specialisation core 3	Specialisation elective	Specialisation elective	Project – part B

Note: 'free electives' may required to be taken from non-engineering areas

Most accredited BEngTech programs have considerable commonality with their BEng

[11] Engineers practice in a defined discipline: Engineers Australia has eight colleges that cover the main areas of practice, and in which engineers may register.

counterparts, but may have less mathematics and science and include more practice and technology based topics to ensure that accreditation (and occupational) requirements are met in their engineering specialisation.

Such common core content and structures, especially during the first two program years, facilitate student transfers **between higher education institutions** with full credit. However, it should also be noted that many engineering educators are adopting non-traditional approaches to deliver what could be considered traditional content. Contemporary engineering education pedagogy, as advocated in the 2008 review (King 2008), emphasises the value of active learning strategies and real world contexts, such as problem-based learning and group design work within the course units, in order to induct students into the engineering profession and to build the required learning outcomes expected of graduates from accredited programs. Many faculties are using a 'top-down' approach to design integrated curricula that focuses on the development and assessment of the required graduate learning outcomes throughout the program and thus facilitates student achievement of those outcomes.

As discussed further in Section 4, articulation from many VET qualifications into program structures of this type poses significant difficulties for students without a sound background and facility in mathematics and fundamental sciences. They are likely to be given academic credit in first, second and even third level courses, including electives, rather than just first-year courses. In consequence, their enrolments tend to include courses from several program-years, often with fragmented timetables that decrease the effectiveness and appeal of on-campus study.

Table 4 shows the numbers of students commencing undergraduate degrees in 'engineering and related technologies' for 1996 – 2009, from the national higher education statistics collection[12]. These data cover commencements into both 3-year BEng Tech and 4-year bachelor degrees (including dual degrees, but not those students commencing into the Melbourne model degrees who may ultimately progress to the MEng program), and show the recent growth in both domestic commencements, from a low point in 2004. They also show the three-fold growth in international student commencements since 1996, and the low rates of participation by women, referred to earlier. Comparison of these figures with those for 'all commencements' into engineering demonstrate that bachelor degree education is indeed the core business of the engineering faculties.

Basis of Admission (BoA) data, as reported in the national statistics for commencing domestic students into engineering degrees, is summarised in Table 5. Here, the data have been averaged over 2001-8 and shown by university group. These data show the relative sizes of each group, with respect to domestic engineering commencements: all together, the fourteen capital city-based institutions in the Go8 and Technology groups admit more than 70% of Australian engineering degree students.

[12] The Australian Standard Classification of Education (ASCED) Field of Education 03, 'Engineering & Related Technologies' includes several areas, such as furniture and clothing manufacturing, that lie outside engineering, and are not supported by university programs. The principal disciplines in FoE03 that are outside engineering but supported by university programs are geoinformatics and surveying, and civil aviation. These disciplines are often covered within university engineering faculties, and their national numbers are small, so aggregated FoE3 data are used in the tables provided here, unless stated otherwise. FoE 02 covers 'Information Technology', including computer science and information systems, and networks and communication. 'Software engineering' is not explicitly identified in either FoE02 or FoE03.

Each institutional group has a characteristic pattern with respect to the relative dominance of one or more BoA category, with secondary school certificate entry clearly most important for Group of Eight universities, and progressively less so for the other groups, as listed. Prior studies in higher education are very significant for the regional universities. Mature entry is very small in the Go8 group, but quite significant for the regional universities. The proportion of students entering with BoA from a TAFE/VET qualification is much more important for the technology, metropolitan and regional universities, some of which are dual-sector institutions.

Table 4 Bachelors Degree Commencements in Engineering & Related Technologies, 1996-2009

	1996	1998	2000	2002	2004	2005	2006	2007	2008	2009
BACHELORS DEGREES	**12,233**	**12,514**	**12,676**	**14,137**	**13,846**	**13,698**	**14,142**	**15,340**	**15,760**	**17,363**
domestic number	10,591	10,895	10,428	10,276	9,908	9,916	10,288	11,051	11,295	12,052
% domestic female	13.7%	14.2%	14.7%	14.5%	13.5%	12.7%	13.4%	14.4%	14.1%	14.5%
international number	1,642	1,619	2,248	3,861	3,938	3,782	3,854	4,289	4,465	5.311
% international female	15.3%	15.6%	19.1%	16.9%	16.6%	17.7%	17.4%	17.9%	17.6%	17.4%
% international	13.4%	12.9%	17.7%	27.3%	28.4%	27.6%	27.3%	28.0%	28.3%	30.6%
ALL ENGINEERING COMMENCEMENTS*	**15,879**	**15,952**	**16,532**	**20,429**	**21,125**	**20,816**	**21,096**	**22,704**	**23,591**	**27,508**
domestic number	13,521	13,522	13,026	14,174	13,745	13,586	13,945	14,312	15,030	16,994
% domestic female	13.9%	14.5%	15.2%	15.0%	14.1%	13.8%	14.6%	15.0%	15.1%	15.5%
international number	2,358	2,430	3,506	6,255	7,380	7,230	7,151	8,392	8,561	10,514
% international female	15.5%	15.5%	17.6%	17.1%	16.4%	17.7%	18.0%	17.9%	18.3%	17.8%
% international	14.8%	15.2%	21.2%	30.6%	34.9%	34.7%	33.9%	37.0%	36.3%	38.2%

*includes all awards from foundation to doctoral.

Whilst overall annual commencing numbers varied by only ±5 per cent over the eight-year period of these data, the proportion commencing with BoA from TAFE/VET ranges from 4 per cent in 2001 to 7 per cent in 2005, remaining above 6 per cent since that year. The secondary school BoA declined fairly steadily from above 71 per cent prior to 2004 to 65 per cent since. However, identifying a single BoA for each student (as presented in the national data) masks the complexity of some students' educational and work histories. All of the students admitted under the composite category 'mature/professional/employment' will have some prior educational qualification; and it can be assumed that many of the students admitted under 'examination by institution' or 'special entry' categories are in fact school-leavers, or TAFE qualified students who have taken aptitude tests for engineering.

Table 5 Basis of admission data for domestic students commencing bachelors programs (3-year, 4-year, dual and honours) in the FoE3 for 2001-8 by institutional group

	Total number (over 8 years)	Proportion of commencements	Higher Educ (complete or incomplete)	TAFE/VET qual. (complete or incomplete)	Mature, prof, employment	Secondary School certificate	Examination by Institution	Other (inc Open Learning and & Special Entry)	Not stated
Group of Eight	**33,692**	40.4%	8.7%	0.8%	0.6%	82.2%	0.8%	5.4%	1.5%
IRU	**8,130**	9.8%	16.5%	6.3%	3.8%	68.4%	0.7%	3.2%	1.3%
Technology	**25,113**	30.1%	16.0%	10.7%	1.4%	61.4%	0.3%	9.7%	0.6%
Metropolitan	**10,832**	13.0%	13.8%	10.2%	4.6%	56.7%	6.1%	8.0%	0.6%
Regional	**5,510**	6.6%	32.5%	8.6%	8.5%	38.2%	2.5%	9.5%	0.2%
All institutions	**83,277**	100%	**13.9%**	**6.1%**	**2.2%**	**68.3%**	**1.4%**	**7.1%**	**1.0%**

Commencing student numbers also need careful interpretation. The DEEWR definition (against which universities provide annual data returns) classifies commencing students as 'enrolled students who are new to the course of study at the provider institution'. The definition excludes students who transfer from a lower level of course to a higher one (such as honours) in the same FoE in the same institution or between single degree and combined degrees that cover the same discipline. Under this definition, a student making an internal university transfer between an Associate Degree in Engineering to a BEngTech program or a BEng program would not count as a new commencement. By contrast, a student making a similar transfer between universities would, over time, be counted as two commencements. The relatively high proportion (13.9 per cent on average) of students with 'Higher Education' as their basis of admission includes such transfers, as well as transfers into engineering from other disciplines, which is known to be small, and possibly, some institutional reporting anomalies. The recent study on attrition reported in more detail on how this 'double counting' of commencements in the national data collection inflates the number of individuals commencing engineering, and contributes to over-estimates of average attrition rates from engineering degrees (Godfrey & King, 2011: 6-20).

This recent study also provided an informative picture of the diversity of admission pathways, and illustrated some of the points made earlier about the complexity of admissions and commencement data. Figure 3 illustrates the pathways taken by 50 non-school leaver entrants into the Bachelor of Engineering program at the University of Technology, Sydney in 2010.

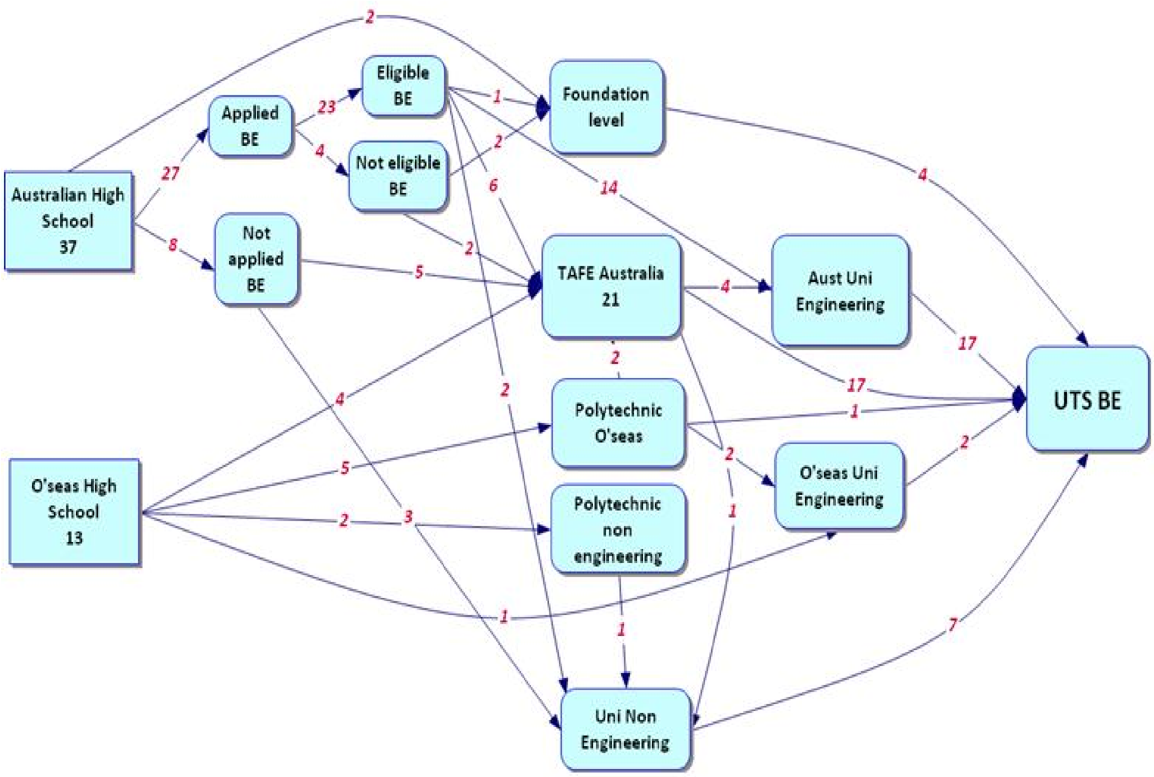

Figure 3 Previous study pathways of a group of 50 non school-leaver entrants to the Bachelor of Engineering program at UTS (from Godfrey & King, 2011: 139)

These students had accepted their offer of admission and attended an in-person enrolment day to negotiate their credit in the BEng program. Of this group:

17 came directly from an Australian TAFE institution

4 came from an Australian TAFE institution via an engineering program at another Australian university

13 came directly from an engineering program at another Australian university

7 came from non-engineering university study

4 came from a foundation study program

The presence of 21 ex-TAFE students in this cohort indicates the importance of university engineering degree providers having the knowledge and resources to ensure that entrants from TAFE programs can gain appropriate levels of credit in their chosen degree, and are supported adequately, alongside their school-leaver peers, to gain their engineering degrees. As Section 4 reveals, this may not be so easy.

2.2 Associate Degrees in Engineering and other higher education pathways

A small number of universities have provided non-degree undergraduate qualifications for many years, and there has been recent growth of Associate Degree programs and student commencements in them. For example, the University of Southern Queensland and its precursor institution has offered one of these programs since 1977. Prior to the 1990's such awards were usually designated as 'Diplomas' or 'Associate Diplomas', but since the introduction of the Australian Qualifications Framework in 1995, most universities have withdrawn these programs and, in some cases, replaced them with Associate Degrees. Diplomas offered by the universities are discussed further in the next section.

Some Associate Degree programs are designed primarily to prepare graduates for work as Engineering Associates; others are designed to provide their graduates with an efficient pathway into a Bachelor of Engineering program. The University of South Australia operates both types: their Associate Degree of Engineering (Defence Systems) is designed to prepare experienced tradespeople for work as supervisors or managers in the defence industry, while the university also operates an Associate Degree as a pathway program (Dowling 2010a). The development of programs is described in detail in (Godfrey & King, 2011: 255-259), and are summarised here in Appendix 4.

When designed specifically as pathway programs, Associate Degrees track their degree 'parents'. They are aimed at students without the normal prerequisites for entry to the engineering degrees. An aptitude test may be used to identify the likelihood of success. The UniSA pathway Associate Degree includes four bridging courses in mathematics and science, the eight common first-year degree courses and a further four courses from the second year of the degree. An Associate Degree graduate would thus gain 12 courses of credit in the 32 course degree (see Figure 3). The university is not seeking accreditation for this program as it does ***not*** contain sufficient occupational content to meet the requirements for accreditation by Engineers Australia as an entry qualification for the Engineering Associate occupation.

In recent years some new Diploma programs have been developed that are linked to follow pre-university Foundation Programs, mostly by international students. Many of them are operated by university colleges (Godfrey & King, 2011: 148). They assist students who are not qualified for direct entry into degrees to bridge their subject knowledge gap, and gain familiarity with university study skills, usually in small classes. Such engineering Diplomas would normally include most of the first year of an engineering degree curriculum.

The growth of commencing enrolments into Associate Degrees in engineering, together with a coarse breakdown of the students' basis of admission is shown in Table 6. In 2009 commencing students entered such programs in three technology group universities, two of the regionals, and one Go8 university. Interestingly, the higher education BoA is quite high for both domestic and international students, probably indicating take up of Foundation Programs. A small proportion of domestic students and international students are admitted on the basis of a complete or incomplete VET award. No international school leavers are entering Associate Degrees.

Table 6 Basis of Admission for students commencing Associate Degrees in engineering (DEEWR data, 2003-9)

(a) Domestic students

	Total numbers	Higher Educ (complete or incomplete)	TAFE/VET qual. (complete or incomplete)	Mature, prof, employment	Secondary School certificate	Examination by Institution	Other (inc Open Learning and & Special Entry)	Not stated
2003	**188**	55	17	30	64	16	6	0
2004	**202**	47	16	33	66	17	23	0
2005	**280**	129	22	23	61	0	45	0
2006	**280**	72	45	36	92	0	34	1
2007	**374**	94	49	38	122	0	69	2
2008	**668**	119	67	67	201	0	211	3
2009	**679**	180	78	70	224	N/A	125	2

(b) International students

	Total numbers	Higher Educ (complete or incomplete)	TAFE/VET qual. (complete or incomplete)	Examination by Institution	Other	Not stated
2003	**8**	0	0	8	0	0
2004	**10**	0	0	0	10	0
2005	**7**	0	0	0	7	0
2006	**42**	32	0	0	7	1
2007	**75**	53	5	0	17	0
2008	**75**	55	9	0	11	0
2009	**82**	56	7	56	19	0

Providers: ANU, CQ University, Swinburne University of Technology, RMIT University, University of South Australia and University of Southern Queensland had commencing students in 2009

Only three university-based Associate Degree programs have been professionally accredited: in civil, electrical, and mechanical engineering at CQUniversity; in civil, electrical/ electronic, mechanical/manufacturing, and network engineering at RMIT university; and in seven engineering disciplines at the University of Southern Queensland. All these programs have an entry requirement of a Year 12 Certificate, or equivalent, including English and general mathematics, with a calculus based mathematics subject recommended (see Appendix 5). Some require commencing students to have work experience.

2.3 Conclusions

Teaching Bachelor of Engineering programs to school leavers is the main teaching activity of the higher education as a whole. Some institutions have relatively more experience of articulating students from VET awards than others. Some providers are actively developing Associate Degree programs and other pathways, for both domestic and international students. Most of these programs parallel most of the content in the first two years of the parent degree program.

Thus the higher education sector itself is providing a growing pool of students with the intention to articulate into degrees. The recent study reported that domestic and international student completions in these awards combined had changed from 314 and 77 respectively in 2005 to 238 and 487 in 2008. The international growth trend over that period is clearer than that for domestic students (Godfrey & King, 2011: 154). That study estimated that amongst the 1,570 domestic commencers (in 2008 – the total was 11,295)) admitted into engineering bachelors degree on the basis of previous higher education studies:

- about 60 per cent would have been inter-institutional transfers (including from pathway programs);
- 25 per cent would be within-institution transfers, possibly from pathway programs other than foundation studies;
- about 15 per cent would have been from internal foundation programs.

The close linkages between the pathway programs and the degrees should not disadvantage those students, relative to school-leaver entrants in the degrees. It would be valuable, nevertheless, for the universities that offer higher education pathways in engineering, to track those students, and institute academic and other support as necessary, to maximize their likelihood of graduation from their degrees.

3 VET Programs in Engineering: qualifications and student numbers as the 'supply' side for engineering degree pathways

In each of the last nine years, about six per cent of domestic student commencements into bachelors degrees in engineering and related technologies, were admitted on the basis of a VET award. That is, about 800 degree commencements per year have a complete or incomplete VET qualification. A small proportion of others, such as those admitted as mature students, or from Foundation Programs, may also hold VET qualifications.

The VET programs that qualify their graduates or students for admission with credit into the university engineering schools are Diplomas and Advanced Diplomas in engineering fields. Some universities may consider trade qualifications for entry into specific Associate Degree programs. Note that graduates from Associate Degrees offered by VET institutions would be classified as entering the engineering degrees on the basis of a higher education award.

This section provides a summary of the provision of these VET awards and the numbers of students graduating from them. This has been developed from previous work (Dowling, 2010a, 2010b & 2011) that explored the provision of education programs for of engineering para-professionals in Australia.

It is important to note that this is **not** a comprehensive review of VET programs in engineering: a broader perspective has been taken in the parallel ANET study (Watson & McIntyre, 2011).

3.1 VET Engineering Awards: Diplomas and Advanced Diplomas

Any organisation that provides vocational education and training (VET) in Australia must be registered as a registered training organisation (RTO). Their award programs must be accredited by the state educational authority before they can be offered: such accreditation is quite separate from the professional accreditation provided by Engineers Australia for specific awards. The VET sector consists of both government TAFE institutions and private providers, and together, they offer a large number of courses, programs and qualifications.

More than 1.7million people were enrolled in VET qualifications in 2009 (NCVER, 2010). Table 7 shows broad student enrolment statistics to situate engineering and the higher level qualifications in the total VET context. In 2009, across all fields of education, enrolments in Diplomas and Advanced Diplomas made up 11.9 per cent and 2.9 per cent respectively of students enrolled in AQF awards, from Certificate 1 to Graduate Diplomas. Enrolments in Certificate III qualifications (including the qualifications for apprenticed trades) contribute the largest proportion (39.5 per cent in 2009). Students in Engineering & Related Technologies (FoE3) programs represent approximately 17 per cent of all students.

Under the national training system protocols, the main VET qualifications in engineering are competency-based National Training Packages overseen by five of the eleven national Industry Skills Councils (ISC). A Training Package "*is a set of nationally endorsed standards and qualifications for recognising and assessing people's skills in a specific industry, industry sector or enterprise* (DEEWR, 2008). Each ISC is responsible for the development, maintenance, and currency of the Training Packages in its industry, and each Training Package lists the set of nationally agreed training requirements for an industry and the full details of all of the qualifications and Units of Competency defined in the Package. The description of each qualification includes: the package rules relating to the core, stream, and elective Units of Competency; and the competencies to be addressed, performance criteria and assessment requirements for each of the defined Units of

Competency. It is important to note that a Training Package describes the competencies, and the performance criteria, required for an individual to perform effectively in the workplace rather than the curriculum for the program.

Table 7 Numbers of students ('000s) in VET qualifications, 2005 - 2009 (NCVER, 2010)

	2005	2006	2007	2008	2009
Associate Degree		0.2	0.3	n/a	0.2
Advanced Diploma	40.5	38.2	34.9	35.0	38.1
Diploma	129.8	127.0	129.2	135.3	157.8
Certificate IV	179.1	177.6	188.7	190.2	218.5
Certificate III	437.7	463.5	476.8	520.1	525.8
Certificate II	249.3	292.6	281.6	287.0	295.6
Certificate I	96.7	98.3	100.1	91.4	90.1
Total AQF awards	**1135.9**	**1199.7**	**1213.1**	**1260.8**	**1330.0**
Other courses	514.9	476.2	451.9	439.0	376.7
In National Training Packages	866.6	956.2	985.7	1059.1	1130.0
In State accredited courses	345.7	332.5	287.6	244.9	233.3
In Engineering & Related Techn's	263.5	284.8	278.8	282.4	283.6
Total Students	**1650.8**	**1676.0**	**1665.0**	**1699.7**	**1706.7**

The awards of interest to the professional engineering disciplines (civil, electrical, mechanical, etc.) are covered by five ISC's (see Table 8). This contrasts with "*most other industry sectors which are covered by just one ISC.*" (Dowling, 2010a), and poses potential difficulties for university engineering faculties and schools seeking to develop smooth articulation paths for engineering, across a number of disciplines.

It is interesting to note that four of the engineering Advanced Diplomas that are defined in Training Packages are **not** currently taught by any of the Australian VET institutions: the Advanced Diploma of Civil Construction; the Advanced Diploma of Civil Construction Design; the Advanced Diploma of Telecommunication Engineering; and the Advanced Diploma of Telecommunication Network Engineering. This means that although an Industry Skills Council has defined a qualification that they believe is important for their industry, none of the VET institutions have decided to offer the program (Dowling 2011). It would be instructive to research the reasons for the lack of take-up of these programs, and explore to extent to which this is due to: a perceived lack of interest or demand for the program in a region; a lack of employment opportunities in a region; or a lack of staff or facilities to teach the program at a given institution.

In addition to offering National Training Package qualifications, VET institutions may develop, and seek state accreditation for, programs in fields not covered by the existing Training Packages. The program design must use the same competency-based approaches to teaching and assessment that are used for Training Packages. Once the proposed program has been accredited by the relevant State Training Authority it is called an 'Accredited Course', and it may then be offered by the initiating institution and by other institutions in Australia. Generally the origin of these state qualifications can be identified by the alpha characters at the end of the program code, e.g. 40604SA is a South Australian accredited course. For consistency with the terminology used to describe other award programs, Accredited Courses are referred to as 'programs' in this report.

Table 8 Advanced Diploma qualifications in engineering developed by Industry Skills Councils (from Dowling, 2010a, after NTIS, 2010)

Industry Skills Council	Packages	Qualification (Program)	Code #
Electrocomms and Energy Utilities Skills Council	UEE07 Electrotechnology Training Package Version 3	Advanced Dip of Electrical Engineering	**UEE60107**
		Advanced Dip of Electronics and Communications Engineering	**UEE60207**
		Advanced Dip of Computer Systems Engineering	**UEE60407**
		Advanced Dip of Industrial Electronics and Control Engineering	**UEE60607**
		Advanced Dip of Instrumentation and Control Engineering	UEE61510
		Advanced Dip of Refrigeration and Air-conditioning Engineering	**UEE60707**
		Advanced Dip of Renewable Energy Engineering	**UEE60907**
Innovations and Business Industry Skills Council	ICT02 Telecommunications Training Package	Advanced Dip of Telecommunication Engineering	ICT60202
	ICT10 Integrated Telecommunications	Advanced Dip of Telecommunication Network Engineering	ICT60210
Manufacturing Industry Skills Council	MEM05 Metal and Engineering Training Package	Advanced Dip of Engineering	**MEM60105**
SkillsDMC National Industry Skills Council	R1109 Resource and Infrastructure Industry Training Package	Advanced Dip of Civil Construction Design	R1160509
		Advanced Dip of Civil Construction	R1160609
Transport and Logistics ISC	TDM07 Maritime Training Package	Advanced Dip of Transport & Distribution (Marine Engineering C1)	TDM60207
		Advanced Dip of Transport & Distribution (Marine Engineering C2)	TDM60307

Notes: bold codes signify that these qualifications were taught in Australia in 2010
the last two digits of the code indicates its approval year.

Some characteristics of both the Training Package and accredited Advanced Diploma programs **currently** offered across Australia in key fields of engineering are listed in Table 9. The Accredited Courses cover such areas as engineering design, structural engineering, aerospace, and oil and gas.

The following points should also be noted:

- The information about the entry requirements and structure of the program is based on that defined in the Training Package or Accredited Course documentation. The structure of an individual program may vary between institutions, as individual institutions may not offer all of the Units of Competency defined for the qualification;
- The number of institutions listed for each state is based on the institutions accredited to offer the program. Some of these institutions may not offer a program every year.

Table 9 reveals that no National Training Package Advanced Diploma is offered in all states, although one or more VET institutions in most states provide Advanced Diplomas from the

UEE06 and MEM05 Training Packages. There are no Advanced Diplomas in any engineering discipline offered in the Northern Territory[13]. Indeed, the study by Dowling (2010a) found that most of the provision of these engineering awards is confined to metropolitan TAFE institutes, and none are offered by distance education. The full list of programs currently available is provided as Appendix 6.

Table 9 National Provision of VET Advanced Diploma Awards (from Dowling, 2010a)

Advanced Diploma of...	Program Code	Required/ Available Units	Number of Institutions offering the full qualification									Entry Requirements
			QLD	NSW	ACT	VIC	TAS	SA	WA	NT	[5]PP	
Civil specialization												
Engineering Design	40604SA	36/99	**2**		**1**	**1**		**1**				Year 12 or Year 11 + Exp
Civil & Structural Engineering	52011	39/44							**2**			Maths & Comms skills[4]
Structural Engineering	91155NSW	31/31		**4**								Year 12
Electrical specialization												
Electrical Engineering	**UEE60107**[1]	13/16 + 41 U[2]	**1**	**4**		**1**		**1**				4-5 years high school, access to workplace
Electronics & Communications Eng	**UEE60207**	12/15 + 80 U[2]	**1**	**1**		**3**		**1**				4-5 years of high school
Computer Systems Engineering	**UEE60407**	12/15 + 80 U[2]	**1**			**9**		**1**				Year 12
Industrial Electronics and Control Engineering	**UEE60607**	12/15 or 13/16 + 45 U[2]		**2**								4-5 years high school, access to workplace
Refrigeration & Air-conditioning Engineering	**UEE60707**	14/17 + 23 U[2]	**1**					**1**				Completion of Cert III
Renewable Energy Engineering	**UEE60907**	13/16 + 45 U[2]		**1**								4-5 years high school, access to workplace
Electrotechnology (Industrial Electronics & Control Engineering)	51974	3/3 + 200h							**1**			Maths & Comms skills[4]
Mechanical specialization												
Engineering	**MEM60105**	30/120	**1**	**4**		**1**		**3**	**2**		**1**	Year 12
Engineering Technology[3]	21622VIC	1400h 74 U[3]		**1**		**9**						Year 12
Engineering (Aerospace)	15696VIC	37/37 + 400h				**1**						Year 12
Mining specialization												
Engineering (Oil & Gas)	52170	30/30							**1**			Maths & Comms skills[4]

[1] Advanced Diplomas defined in a National Training Package are shown in bold type. [2] The Unit Stand Total (UST) is the sum of the strand values of the units completed. [3] Students must complete 1400 hours of study from the 74 available Units, each of which has a defined hour value.[4] Well developed maths /communication skills. [5] A private RTO that may offer the program in one or more states.

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[13] Charles Darwin University has offered curriculum-based Diplomas in civil and mechanical engineering since 2009, and Advanced Diplomas from 2011 (Godfrey & King, 2011: 144).

To date, only one Advanced Diploma has been professionally accredited by Engineers Australia[14]: the Advanced Diploma of Engineering Technology program offered by the Chisholm Institute of TAFE, with two accredited majors, in Mechanical Design, and Robotics and Mechatronics.

The 'Required/Available Unit' data in Table 9 shows that there is great diversity in the structure of the engineering Advanced Diplomas, even within one engineering specialisation area. There are also no (or few) shared Units between Training Packages or Accredited Courses, since the ISCs (and providers) develop their packages and programs independently. Whilst programs with a diversity of units offer students choice so they can accommodate their interests, such choice does not guarantee that graduates have the expected depth and breadth of knowledge and skills to practice in their designated engineering disciplines, as required for professional accreditation, or for articulation into an engineering degree program.

The Advanced Diploma of Engineering (MEM60105) is used to illustrate this point. Students must complete all six of the core Units, which mainly cover generic skills, and 24 of the elective Units. The elective Units, which cover all of the key fields of mechanical engineering, are in two groups, with students selecting up to eight of the 35 Units in Group 1 and at least 16 of the 85 Units in Group 2, including four Units of free electives, i.e. any of the Units offered by their institution. Of course, this degree of flexibility may not be available at each institution, because they do not offer all of the Units defined for the qualification. However, the degree of flexibility may be expanded for individual students as they can seek to be assessed against the competencies associated with one or more units through the recognition of prior learning system (RPL). Their demonstration of competency may be based on prior studies and/ workplace learning. It should also be noted that many of the Units in the two groups are at AQF Level 3 or below, which will influence credit arrangements with universities. As discussed further in Section 4.2, the diversity of Training Package content is the main reason that universities have been unable to standardise credit for articulating students.

In June 2009 the Ministerial Council for Vocational and Technical Education (MCVTE) endorsed the *VET Products for the 21st century* report (NQC 2009) and the recommendations included in that report were implemented by the National Quality Council (NQC) in 2010. The report included the following recommendations:

> ***"Recommendation 6**: In order to maximise consistency, flexibility and responsiveness, undertake a full and comprehensive review of:*
>
> - *packaging rules as applied in Training Packages to ensure maximum flexibility and consistency within and across Training Packages and Accredited Courses, where both possible and appropriate;*
> - *the use of units from accredited courses within Training Packages; and*
> - *the process for developing and approving Accredited Courses including:*
> - *how duplication of training package content and coverage is identified and resolved;*
> - *improving consistency between state accrediting bodies and across the Industry Sills Councils.*
>
> ***Recommendation 14**: Ensure that Training Package developers include articulation arrangements in the design and development of Diploma and Advanced Diplomas where appropriate."*

[14] Engineers Australia formalised its Accreditation System for evaluating competency-based Engineering Associate qualifications in 2010.

(NQC 2009 pp. 6-7)

The recommendation to increase the flexibility in VET Training Package qualifications was strongly supported by employer groups. However, there is a tension between the stated need for increased flexibility in these qualifications and the need for a substantial defined core that will ensure the accreditation of engineering programs by Engineers Australia and facilitate articulation into a degree program. Recommendation 14 may go some way to resolving this tension as Industry Sills Councils will have to address articulation when developing or revising Training Packages. However, the success of this initiative will depend on how this recommendation is interpreted and implemented by each ISC.

These issues are taken up in more detail in Section 4.

3.2 Graduating Numbers from VET Diplomas and Advanced Diplomas in Engineering

To assess the potential of VET Diplomas and Advanced Diplomas in engineering disciplines to provide significant numbers of students to articulate with credit into degree programs, we first need to know the numbers of graduates from these qualifications. Table 10 has been compiled from NCVER data, and shows the total numbers of students who completed Diploma and Advanced Diploma awards in programs that relate directly to the grouped engineering disciplines in 2008.

Table 10 (a) VET Diploma completions in engineering areas in 2008, with international completions shown in parenthesis

engineering discipline area	NSW	VIC	QLD	SA	WA	TAS	ACT	ALL
Civil	43		9	37	105 (13)	16	7 (1)	**217 (14)**
Mech/ Manuf/ Auto/ Aero	145 (3)	416 (187*)	100 (10)	47 (1)	95 (20)	21	5	**728 (221)**
Elec/ Comp/ Telecoms	354 (2)	31 (2)	120 (3)	18 (2)	69 (10)	4		**596 (19)**
Mining (inc. mine surv. & mgt)	36	35			60 (5)			**186 (5)**
Other or not specified		2	10		34			**46 (0)**
Total Diploma	**542 (5)**	**484 (189)**	**239 (13)**	**102 (3)**	**329 (48)**	**41 (0)**	**12 (1)**	**1,773 (259)**

* 177 of these are from one Diploma of Motorsport

Table 10 (b) VET Diploma completions in engineering areas 2008, with international completions shown in parenthesis

engineering discipline area	NSW	VIC	QLD	SA	WA	TAS	ACT	ALL
Civil	97 (9)	42 (13)	6	4 (1)	33 (4)	8	8 (1)	**198 (28)**
Mech/ Manuf/ Auto/ Aero	56	321 (26)	71 (51)	33 (1)	31 (10)	11 (3)	12	**535 (91)**
Elec/ Comp/ Telecoms	320 (11)	286 (59)	112 (2)	15 (1)	11 (1)	6 (2)	4 (1)	**764 (77)**
Mining (inc. mine surveying)	9	1 (1)	2		13 (1)			**25 (2)**
Other or not specified							1 (1)	**1 (1)**
Total Advanced Diploma	**484 (20)**	**650 (99)**	**191 (53)**	**52 (3)**	**88 (16)**	**25 (5)**	**25 (3)**	**1,523 (199)**

Notes: whilst total completion numbers are correct, the NVCER data may understate the number of international students in each category.

The numbers in some disciplines, such as civil engineering, and in some states appear to be very low at a time of severe skills shortages in many fields of engineering, particularly in infrastructure. Given the growth of Associate Degrees in both VET and higher education, aggregating the data for all of these awards may be a valuable way of understanding the student demand and supply for these award levels.

The numbers of Diploma and Advanced Diploma graduates appear to be reasonably stable over the past five years, allowing broad deductions about articulation rates to degrees. If it is assumed that many of the Diploma graduates progress directly into Advanced Diploma studies, the total numbers of domestic VET graduates available for industry and pathways to higher degrees is likely to be approximately 1,500 per year. With, on average, some 6 per cent of about 11,000 students commencing engineering degrees are admitted on the on the basis of a VET qualification, the implication is that about 40 per cent of (successful) students in VET Diplomas and Advanced Diplomas in Engineering actually articulate into degree studies. A further reasonable assumption is that universities are more likely to admit students who have completed their Advanced Diplomas within a few years of seeking articulation, rather than those with Diplomas or incomplete study.

Given the broad societal trends (and the explicit government goal) towards increasing bachelors degree graduations, a tentative conclusion that may be drawn from these assumptions and the data is that – at least over time – there are likely to be relatively fewer Advanced Diploma graduates available for full-time employment as career para-professionals. This conclusion is supported by Dowling's study (2010b) that found that only 16 per cent of the 327 Associate Degree, Diploma and Advanced Diploma students who completed the online questionnaire had a career goal to work as Engineering Associates. Of the remaining students, 51 per cent had a career goal to work as Professional Engineers, 16 per cent as Project Managers and 4 per cent as Engineering Technologists. Further analysis of this data revealed that only 26 percent of the Diploma students and 18 percent of the Advanced Diploma students planned to work as Engineering Associates, with 41 percent of the Diploma students and 54 percent of the Advanced Diploma students having a career goal to work as a Professional Engineer.

However, this conclusion, and the assumptions and data need further investigation with respect to addressing Australia's apparent skills shortages of para-professionals in engineering, and the low levels of recognition of the Engineering Technologist occupation.

3.3 Provision of Associate Degrees in Engineering by VET Institutions

In recent years a number of single-sector VET institutions have moved to offer Associate Degrees in engineering, and more are likely as New South Wales TAFE announced in September 2010 that it would be developing curriculum-based higher education award programs. To do this, providers must develop the program and have it accredited by the relevant state higher education authority. These programs are curriculum-based, with their structure and content determined by the institutional provider with input and advice from industry, and are accredited (educationally) by the relevant state accreditation authority. Dowling (2010a) identified three, of which two have identified pathways into engineering degrees. Summaries of their objectives, content and entry requirements, taken from websites, are provided in the following paragraphs.

Polytechnic West: Associate Degree in Aviation (Aircraft Maintenance)
http://www.hotcourses.com.au/australia/course/associate-degree-in-aviation-maintenance-engineering-polytechnic-west/51808018/115249/coursedetail.html

This program caters for licensed aircraft [maintenance] engineers, aviation engineering supervisors and aviation engineering consultants. This program provides the student with the strong theoretical and practical foundation required by the licensed aircraft maintenance engineer, as well as a sound knowledge of the principles of management, marketing and commercial law. The course prepares students for employment as an aircraft maintenance engineer, and for relevant licensing examinations.

The program includes: Aviation engineering mathematics, Aviation engineering physics, Aircraft materials and hardware, Aerodynamics of flight, Aeroplane structures and systems, Aircraft instrument systems, Aircraft maintenance practices, Aircraft engines (piston and gas turbine), Aircraft electrical and avionics systems, Aviation security and Management, Economics, Accounting and Legal Principles.

The entry requirement is successful completion of an Australian year 12 or equivalent international qualification.

Southbank Institute of Technology (Brisbane): Associate Degree in Civil Engineering
http://www.southbank.edu.au/site/about/faculties/designArtsHosp/civil.asp)

This program develops design and drafting skills for a variety of public facilities such as roads, pipelines, dams, bridges, steel and concrete structures. Graduates of the program could expect to find work in a range of positions at para-professional level, most commonly as design drafters using computers in the production of CAD 3D models and drawings for roads, pipelines, dams, bridges, high-rise buildings etc. Some graduates, who prefer to work in the field, may choose to find employment as engineering surveyors, soil technicians, or site supervisors.

The 16 subject program covers CAD, road design, geosciences, surveying and construction. A Diploma of CAD is embedded within the Associate Degree. Students may apply to study the Associate Degree as a discrete qualification, or as one of three articulated options, which provide direct entry upon successful completion of the Associate Degree to bachelors degrees in civil engineering at QUT or USQ.

The entry requirement is Completion of Year 12 or equivalent with a Sound Achievement in English, or a recognised Certificate III or IV, and achievement of Year 12 Maths A or equivalent is assumed.

TAFESA: Associate Degree in Electronic Engineering
http://www.tafesa.edu.au/xml/course/aw/aw_ADD.aspx

The graduates of this qualification will have strong analytical skills and solid hands-on skills to be utilised for the testing, modification, design and integration of hardware and software in complex electronics systems. Graduates can find employment as technical officers in the electronics industry and related areas like defence, mining, biomedical, etc. The qualification is designed to maximise the amount of credit obtained for higher education degrees, with the BEng in Electrical & Electronics Engineering at the University of Adelaide allowing up to two years credit.

The program has 23 defined core and elective subject units, to develop skills in: using advanced mathematical skills to solve problems in electronics; solving engineering problems involving motion and laws of electromagnetism; designing and testing of software related to practical engineering applications; designing, developing, testing, commissioning and maintaining electronic systems as used in electronics equipment; designing and testing of advanced analog, digital and RF electronic circuits; designing software and hardware for microprocessor interfacing; using computer simulation and CAD tools; managing electronic projects.

The entry requirement is satisfactory completion of SACE Stage 2 (or equivalent) including a Satisfactory Achievement in Mathematics, any Certificate III in Engineering, or Satisfactory Achievement in the Special Tertiary Admissions Test (STAT).

In addition to the above programs, the TAFE institutes within 'dual sector' institutions in Victoria also offer Associate Degrees in Engineering. Some emphasise the pathway outcome, and are aimed to attract "*students who are capable but less prepared for university, and provide an excellent link between secondary school and the independent learning expected at university with the benefit of smaller class sizes and more support from the academic staff through more on-campus contact hours*." (from the Swinburne University website). Examples include:

RMIT University: Associate Degree in Engineering Technology with separate strands in: Advanced Manufacturing; Aerospace-Mechanical;Design & Development; Systems and Logistics; Civil Engineering;Network Engineering; and Electrical/Electronics Engineering.

Swinburne University: Associate Degree in Engineering provides an introduction to the foundation studies of civil, mechanical and electrical engineering, together with engineering management and a range of vocationally orientated subjects in preparation for employment in a dynamic and changing workforce. The course consists of 1.5 years of university engineering degree units of study and 0.5 years of vocationally-orientated TAFE units of study. It provides the opportunity for successful students to articulate automatically on completion into the relevant degree course with up to 1.5 years of advanced standing.

The Associate Degree programs in universities (Section 2.2) and in TAFE institutes (as above) are clearly providing additional pathways into engineering degrees, as well as an additional qualification route to para-professional practice in engineering. The defining characteristic of these awards, compared with the VET Diplomas and Advanced Diplomas, is that they are curriculum-based, and frequently incorporate specific higher education course units (sometimes in small classes), so that, at least that in principle, their articulating graduates are better prepared for their more advanced degree studies.

Another important characteristic of the Associate Degree programs offered by CQUniversity and USQ is that they are available by distance education. They are popular with students who work full-time as well as students who find it difficult to access on-campus programs offered by other VET and HEd institutions. While the majority of students in these programs are from Queensland and northern NSW, they also attract students from metropolitan, regional and rural areas across Australia.

4 Pathways between VET qualifications and engineering degrees: issues and barriers

This section discusses the operation of the pathways between VET qualifications to engineering degrees. The main focus is on the pathways from the VET Diplomas and Advanced Diplomas, rather than on the Associate Degrees that have between specifically devised as pathway awards by including early year degree content. There are three main **operational** aspects of pathways: the award of credit for the VET qualification, timetabling issues for on-campus students, and the success rate of VET graduates in their degrees. Students also have **personal** reasons that affect their progress. Whilst many of these relate to balancing employment, personal commitments and study, a **systemic** issue is that some high-demand trade qualified employees may suffer loss of pay and conditions in making a move to a paraprofessional or higher occupation (Hamilton, 2009). This prospect, together with the time investment in study, is a likely deterrent to progress.

These aspects of pathways were explored with engineering faculties and schools that participated as partners in the ALTC-funded study (Godfrey & King, 2011) In particular, the attrition theme of that study (based on cohort studies at eight universities) revealed the main factors that contribute to student attrition from engineering degrees, while the pathways study, involving representatives of the nine universities listed below (mostly different from those in the attrition study), and other individuals, provided both evidence of successful practice and the barriers to success.

Higher Education Institutions	Dual-sector Institutions
University of Technology, Sydney	Swinburne University of Technology
CQUniversity[15]	RMIT University
University of Southern Queensland	Victoria University
University of South Australia	University of Ballarat
	Charles Darwin University

This section of the report draws on that study, and also on responses from Curtin University, Deakin University, the University of Wollongong, Edith Cowan University, La Trobe University and the University of Western Sydney to a request for information about the operation of their pathways for students with VET qualifications.

4.1 Award of Credit for VET or Higher Education Qualifications

Applicants admitted to degrees in three specific Basis of Admission categories are entitled to be considered for commencement with advanced standing, and have credit awarded for their previous studies. The three categories are:

- a complete or incomplete higher education award, including foundation studies, higher education diploma, advanced diploma, associate degree or other bachelors degree. (On

[15] CQUniversity has entered discussions with the Queensland Central Institute of TAFE with a view to becoming a dual sector institution.

average, 13.9 per cent (some 1,500) of all engineering bachelors degree commencers are in this category);

- a complete or incomplete VET award (assumed mostly to be at AQF Level 5 and above), (6.1 per cent, or about 635 students);
- professional employment or prior learning as a mature applicant (2.2 per cent).

In addition, it should be noted that while Certificate III graduates are unlikely to be admitted directly into a bachelors degree program, they may be admitted to an Associate Degree with some advanced standing. The requirements and credit on entry for such students to the University of Southern Queensland are provided in Appendix 5.

Applicants in the latter two categories are entitled to have credit granted in accordance with the national credit transfer and recognition of prior learning (RPL) guidelines, developed and agreed by the (then) Australian Vice Chancellors' Committee (AVCC), and overseen by AQF since 2002. The current generic recommended amounts of credit (which may be varied by circumstances) in bachelors degrees, are:

- 50% credit for an Advanced Diploma, when linked to a 3-year Bachelor Degree
- 37.5% credit for an Advanced Diploma, when linked to a 4-year Bachelor Degree
- 33% credit for a Diploma when linked to a 3-year Bachelor Degree
- 25% credit for a Diploma when linked to a 4-year Bachelor Degree

Thus the recommended credit for Diplomas and Advanced Diplomas are equivalent to one and one and a half academic years, respectively. Applicants with VET qualifications will be assessed by the university against the requirements of the specific degree program into which they are seeking admission. Whilst the university is required to comply with the national guidelines on credit transfer, in practice, most engineering faculties have found it difficult to apply these amounts of credit in block form, and they expend considerable time, energy and resources dealing with credit transfer on a case-by-case basis. The reasons cited for this are:

- the high levels of flexibility in the core and discipline units in the VET awards does not guarantee core coverage of mathematics, science and engineering principles; and
- the need to facilitate successful outcomes by providing each student with the required pre-requisite knowledge and skills in each field of study before they tackle higher level subjects.

To illustrate the complexity of the entry considerations, the Guidelines used for admission of TAFE Advanced Diploma holders in the Bachelor of Engineering at Curtin University of Technology are provided in Appendix 7. This shows how universities have to maintain records of previous VET awards, as well as current ones.

4.1.1 A dual sector exemplar: RMIT University

A **best-practice case** of applying the AQF guidelines in engineering is operated by RMIT University. In summary, RMIT makes the following provisions for graduates of the VET awards provided by the RMIT Division of TAFE:

- 1.5years credit for an Advanced Diploma articulating into a two-year Associate Degree;
- 1.5 years credit for an Advanced Diploma articulating into a four-year Bachelor degree, or 2 years if the Advanced Diplomas is awarded with merit;
- 1 year credit for a Diploma articulating into a two-year Associate Degree;
- 1 year credit for a Diploma articulating into a four-year Bachelor degree

- 2 years credit for an Associate Degree when linked to a four-year Bachelor degree

These articulation pathways are shown diagrammatically in Figure 4. RMIT made a non-negotiable decision to adopt the AQF guidelines on pathways and automatic credit transfer, and leverage its dual sector advantage to maximise the opportunities for students to articulate between qualifications. To this end, boundaries between the sectors and qualification have somewhat dissolved, and policies and practices have resulted in sustainable culture change, with processes of curriculum mapping and credit transfer no longer reliant on *ad hoc* or case-by-case arrangements. This is one of the advantages that dual-sector institutions have compared to other institutions.

In engineering disciplines, RMIT has accommodated awarding credit to VET Advanced Diplomas that are based on national training packages and that do not have graded assessment. It has, nevertheless, found it necessary to introduce academic merit assessments and thresholds to guarantee entry to some of the programs eg Aerospace Engineering, and in other cases specific articulation agreements between TAFE and HEd programs have documented the exact requirements of the pathway.

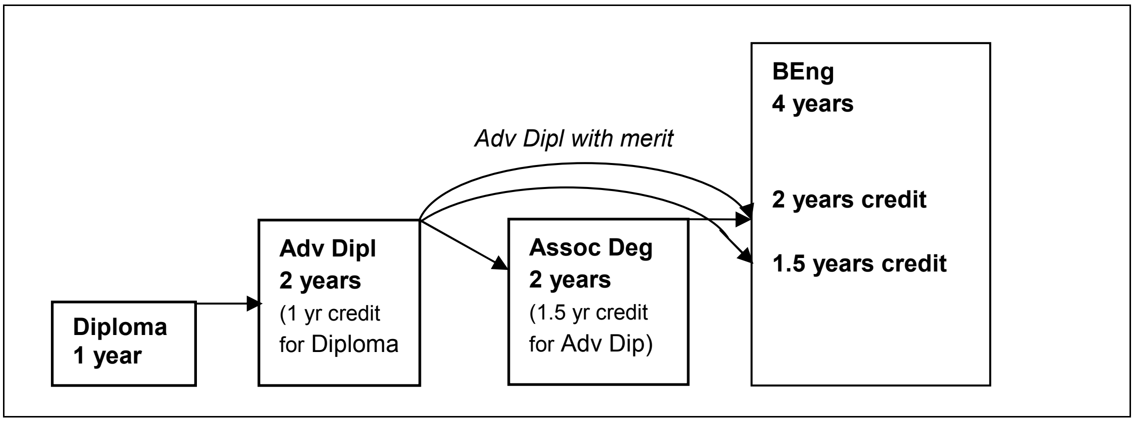

Figure 4 Pathways from VET awards to the BEng degree at RMIT

Specific curriculum mapping of the advanced diploma, associate degree and BEng programs has been carried out to ensure easy negotiation of articulation pathways, as well as efficient delivery of each of the programs. Students articulating from the TAFE awards can study some first or second-year degree courses to ensure pre-requisite knowledge, and some degree courses require specific technical courses to be taken as electives to ensure maximum credit transfer. RMIT staff also reported (Godfrey & King, 2011) that:

> "*staff at RMIT acknowledged that considerable energy, negotiation and compromise have been required to restructure courses and curricula. This commitment is ongoing and new programs being developed, or current programs being amended, must include articulation pathways in their documentation which assists in the ongoing synergy between the two sectors*".

Operating as a dual sector institution, RMIT can track individual student progress (with a common student ID) while taking units from both educational sectors. Although they may be qualified for direct admission to RMIT BEng programs, many students have been choosing the Associate Degree pathway deliberately, while planning from the start to articulate into BEng. The most recent data available indicates that at least 50 per cent of Associate Degree graduates are articulating into BEng programs at RMIT, and anecdotal evidence suggests that in some engineering fields, up to 90 per cent of students intend to articulate into BEng programs at RMIT or elsewhere.

RMIT believes that the Associate Degree has been a significant contributor to the increase (from 6 per cent in 2007 to 25 per cent in 2009) in the proportion of students entering by articulation into the BEng degree. The structure of the Associate Degree includes more fundamental and academic skills within the discipline compared with the TAFE Advanced Diplomas which are being driven by specific national competency standards that target specific workplace skill sets. This Associate Degree also includes higher level content and skills which is integrated with appropriate levels of both practical knowledge and skills.. Some students who might otherwise have enrolled directly into the degree may have preferred the Associate Degree because of its smaller classes and good balance of competency-based and curriculum-based pedagogies. This model should be a used as a template when a VET institution and University form a close partnership to develop and implement efficient pathways.

While there are no current formal agreements with other local providers in relation to articulations, RMIT policies accept that nationally recognised TAFE programs should attract a consistent recognition at RMIT providing that they are assessed to be in the same field.

4.1.2 A University exemplar: the University of Southern Queensland

As shown in Figure 5, the University of Southern Queensland's suite of articulated engineering programs offers students from a variety of backgrounds, including VET, the opportunity to commence their studies in the Associate Degree of Engineering program and then, if they wish, progress through to the higher level programs to achieve their career goals. The Associate Degree in Engineering has relatively open entry when compared to degree programs and provides students with the opportunity to undertake foundation mathematics and science studies before they begin their engineering studies. In this sense, this program allows students to experience university studies and, if successful, demonstrate their aptitude to undertake higher level studies.

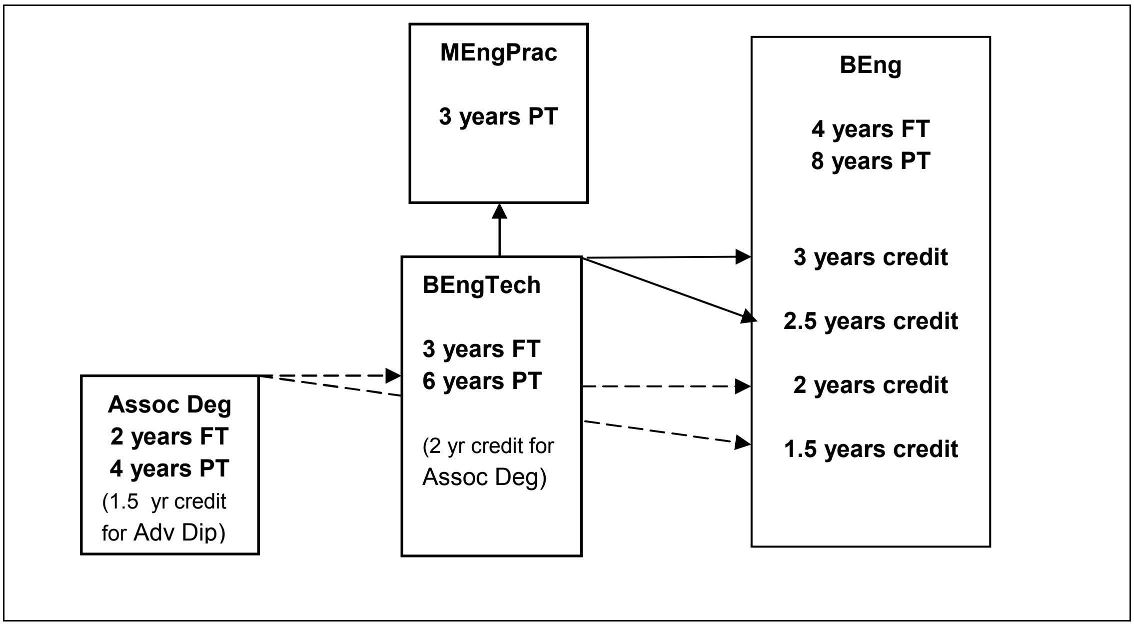

Figure 5 Pathways to the BEng degree at USQ

Most distance education students choose to, or are advised by their employer to begin their studies in the Associate Degree program. The main reasons for this are: they can graduate after just four years of part-time study compared to six or eight years of study for a degree; they may be employed under a formal four year cadetship; they expected to be promoted and/or receive a salary increase once they graduate; and they can use the award to seek alternative employment once they graduate. If these students have planned from the start to articulate into a BEng program then they can seek approval, based on demonstrated ability, to follow to follow a fast track plan to the BEng and receive full credit for their studies in the Associate Degree. Under this plan the students study some additional BEng courses in place of the equivalent Associate Degree level courses.

Like all of the USQ engineering degrees, the Associate Degree of Engineering is offered by distance education and provides opportunities for students who are unable to access a VET institution, as well as those who have completed a VET qualification and wish to articulate into a university program. The fact that all of the programs are available by distance education means that graduates from VET programs, and others, are able to work full-time and study part-time. The portability of this study mode means that these students have the flexibility to change employment and move to a new locations in Australia, or globally, and continue their studies.

4.2 Progression of VET-qualified students in engineering degrees

Concerns about the completion rate of bachelors degree students in engineering underpinned the detailed cohort studies in eight universities undertaken in the ALTC project (Godfrey & King, 2011). In summary, that study found institutional graduation rates in engineering bachelors degrees in the range 40 – 75 per cent for the 2003[16] commencing cohorts, and an overall average of about 65 per cent (Such rates are slightly higher than those reported in a comparable study of engineering schools in the USA, (Ohland., et al, 2008)). The main attrition loss from the Australian degrees is during the first two years of study, in the range 14 – 35 per cent across the institutions studied, but some of this 'loss' is actually articulation to another engineering program at another institution (as illustrated in Figure 3).

The study examined in some detail the characteristics of students who failed to compete their degrees, and also undertook surveys of continuing students, and a small number of those who had withdrawn from engineering. Not surprisingly, students leave engineering primarily because of: a lack of commitment and passion for the subject; a lack of academic progress; or because they find that engineering fails to meet their expectations.

The study reported that students articulating from VET qualifications tend to have good motivation to succeed, but they also have higher attrition than students admitted with advanced standing from higher education qualifications (eg Associate Degrees, Foundation Programs and from other degree programs). Typically, the VET-qualified student is mature, has family and employment commitments and is studying part-time. At times of workforce shortages, highly employable technically-qualified VET graduates are in demand by employers, which clearly creates tension for those who are attempting to continue to study while working. The cohort study found that such students tend to have very delayed graduations, if they do continue their studies through to completion.

[16] The 2003 cohort was chosen so that the true graduation rates could be determined, given that many students take much longer than minimum time to complete. The national aggregated course pass rates ("success rates" in DEEWR statistics) and retention rates for engineering have increased over 2001 – 2008. Graduation rates for students commencing post 2003 should be higher than the 65% reported here.

The statistical analysis, using decision-tree modeling, found from the total sample of 3,139 commencing students, that the group with the lowest chance of success (less than 20 per cent was comprised of domestic students who had entered on the basis of previous VET studies or on mature or special entry criteria. One of the institutional analyses found that students entering first year with little or no credit for their VET qualification had only a 58 per cent likelihood of progressing to second year. This group was also at high risk of leaving after second year. The content of the first two years of the engineering degree program (Table 3) is clearly a better fit to the academic background of a school leaver entrant, than a graduate from a competency-based training package qualification.

These quantitative findings substantiate Dowling's observation, that:

> "*Anecdotal evidence suggests that the variability of Advanced Diplomas is one of the reasons why some qualifications are not well regarded in the industry or by some senior TAFE teachers. It is also the main reason why universities are reluctant to develop standard credit arrangements for graduates of these programs as staff believe each student's academic transcript must be individually assessed. Where credit arrangements have been negotiated between institutions, it is normally on the basis that students will complete a defined set of Units in their program, with minimum electives.*" (Dowling, 2010a).

The low graduation rate achieved by VET-qualified students also suggests that there are systemic barriers to their success, as discussed in the next section. Our findings also point to the absolute need for university engineering schools to provide higher levels of academic (and other) support for the VET-qualified students that they admit, with academic credit, into their degrees. Accordingly, the study proposed a number of actions that could be taken by the engineering schools to increase the likelihood of success of VET-qualified entrants to their degrees. These are set out in Section 5.

4.3 Barriers to the success of VET-qualified students in engineering degrees

The ALTC study held two forums of collaborating partners (including representatives from TAFE institutions) to discuss barriers to the success of articulation from VET programs, particularly Advanced Diplomas. The following pages provide the findings from these forums and some additional observations from subsequent studies.

4.3.1 The competency basis of VET Diploma and Advanced Diplomas and inconsistencies in their assessment

Conceptual and operational differences between competency-based VET awards and curriculum-based Associate Degrees and bachelors degrees are major barriers to successful articulation, and limit the scope for granting full credit (eg. two years for an Advanced Diploma), as urged under the AQF guidelines.

Through its accreditation requirements, the global engineering profession promotes concepts of coherence ***across*** the engineering disciplines, and ***through*** its progression of qualifications (Figures 1 and 2). Australian HEd providers acknowledge this through their initially broad curriculum in their Associate Degrees and bachelor degrees (Table 3) and articulation pathways that build on common blocks of core content.

In contrast, as noted earlier, the five Industry Skills Councils that define engineering Advanced Diploma qualifications in their National Training Packages, do not explicitly identify with engineering as a broad profession or interlinked sets of occupations. The ISC's appear to work largely independently of each other in defining the Units of Competency that make up the awards qualifications for which they are responsible. While the focus on specific employment-related skill sets is entirely appropriate for training to AQF Levels 1 – 4, this is not adequate at Levels 5 and 6, where a more comprehensive understanding of scientific and engineering principles is needed for both effective employment within an engineering team, and to underpin the acquisition of new knowledge, and its application to providing sound and innovative engineering solutions to new problems.

A further aspect of the VET awards that impacts on the assessment of credit is that not all VET institutes grade student achievement, although this is changing. Furthermore, while the Training Packages are defined nationally, there is no common national standard of competence against which their delivery is examined. As Shreeve (2010: 27), CEO of Skills Australia, states:

> *"Quality is the biggest immediate issue for VET. Currently there is little publicly available data to prove that individual providers—public, private or enterprise-based—achieve quality outcomes for their clients and employees. ….. until assessments are regularly externally moderated and validated across providers, industry and individuals cannot have real confidence that a certificate III issued by one registered training organisation is to the same standard as a certificate III issued by another. This is a big and expensive task and may only be possible by charging learners a fee for every credential issued."*

Some participants in forums convened for the ALTC project also recorded their experience from progression tracking of students articulating from VET awards, in terms of them having a "*drop of 25-30 percentage points in the GPA in moving from TAFE to HE*" at Swinburne University of Technology; and at another institution, "*39% of articulating students with an advanced diploma withdrew within two years, and only 3/19 had no fails*". Another participant reported that a competency-based education is "*poor preparation for university study as it encourages students into a mentality of pass, forget and go on to the next unit*". While many students may withdraw for academic reasons, others may withdraw due to the pressures of juggling family, work and study commitments, university timetables, and the long term study commitment, which is exacerbated by each fail.

These data and observations demonstrate the considerable mismatch between the two types of award qualification.

4.3.2 Curriculum mapping between VET qualifications and HE programs: variations in credit transfer

Generally each HEd institution has to develop and document the amount of credit allowable for each combination of VET awards and provider institution. Ideally, HEd providers would build (and share) their credit databases from a basis of curriculum mapping between the qualifications. Forum participants commented that this is becoming more difficult as the range of VET qualifications increases, and the ISC's that develop the Training Packages do not have potential articulation of their graduates in mind.

The ALTC project forum participants acknowledged that VET graduates from the VET institutions have high levels of hands-on skills needed by industry, and that competency-based assessment is appropriate. However, a critical content issue (for articulation) from VET diplomas and advanced diplomas is the absence of mathematics and underpinning science. Where such content is included in VET awards it may not be equivalent to Year 12, let alone to first-year university level (see below). For example, a number of civil engineering Diplomas include two or three fluid mechanics units, but these are taught without first-year HEd mathematics. Participants in the forums referred to examples where units in the mechanical engineering diploma were at AQF Levels 1 – 3 (ie trade and below). They also reported that the depth to which a topic is taken may not be immediately apparent from its title or brief description, even when they appear to match the HEd equivalents.

The outcome is that most HEd providers have built credit databases and guidelines but still need to assess almost all applicants on a case-by- case basis. Historical patterns of assumptions of block credit are becoming less applicable with the majority of institutions seeking 'content overlap' rather than full credit.

Amongst the focus group participants, only one institution, RMIT, appeared to have a commitment to following the AQF guidelines for maximum credit transfer (see Section 3.2) of their Diplomas and Advanced Diplomas. This is operationalised in the university's academic policy by requiring every VET award program to provide evidence of articulation pathways. Such an outcome is positive for the students, as those aspiring to articulate know exactly what they have to do. Swinburne University, another dual-sector participant, however, reported that they have been unable to offer the full block credit.

Basis of Admission data (Appendix 6 reproduces that for the partners in the ALTC projec) show that there is a much higher proportion of VET – HEd articulation in engineering in the dual-sector institutions, reinforcing the national picture of very low articulation to the research-intensive (Go8) universities and only moderate levels at the others (Wheelahan, 2009). Universities in the regional and technology groupings are the dominant participants in this market. This is partly an outcome, *inter alia*, of the amount of credit offered by the university groupings, but also the lack of VET Diploma and Advanced Diplomas in engineering outside the metropolitan centres delivered either on campus or by distance education.

The credit awarded for VET awards ranges widely: some HEd providers in the Go8 group report giving no credit or only one subject. The focus group participants discussed whether giving more credit to such students benefits them, or places them at risk. The need to do case-by-case assessments is reinforced by the perceptions of a lack of consistency in the quality of learning outcomes from different VET institutions offering the same Training Package qualification.

Clearly, considerable resources in the HEd sector are being applied to assessment of credit for VET Advanced Diplomas – and the individuals who possess them – but with different outcomes amongst institutions. Dual sector institutions do, of course, have the advantage of being able to negotiate block credit in-house. The lack of national consistency in the provision and delivery of the VET Advanced Diplomas clearly limits their scope as both occupational qualifications and as a basis for articulation to bachelor degrees in engineering. There is, it must be said, general goodwill between the VET and HEd sectors to cooperate in this area, while working to their respective primary missions.

Taking a broader perspective, Shreeve (2010 p 31) comments:

> "*For 20 years we have had initiatives to provide articulation and credit transfer from VET diplomas to university degrees. The return on these initiatives has only on a limited number of occasions matched the effort. Some universities have difficultly aligning competency-based diplomas with knowledge-based degrees.*"

Shreeve's analysis is largely borne out in engineering. Shreeve continues:

> *"Another factor in Australia's less-than-optimal performance in VET-to-university pathways is*

that many universities do not for financial reasons want to give up teaching the first year of their programs. This is almost certainly the reason why the strongest transfer programs are often those from university-owned or franchised foundation colleges."

For engineering this is a much more contentious position. The occupational goal of a Diploma or Advanced Diploma in engineering is to produce a skilled paraprofessional: someone who should have more specific knowledge and skill in a given technical area (such as computer-aided drafting or maintenance systems), than their Professional Engineering supervisor. This is very different from the expectations of a first year engineering degree curriculum that usually concentrates on providing the knowledge base in mathematics and science and an understanding of the principles and practice of engineering (Table 3). Given the current disposition of VET engineering programs, it is far from clear that the VET institutions have the staffing and facilities to deliver first-year engineering degree curriculum.

4.3.3 The VET Advanced Diplomas lack preparation in mathematics

The absence of mathematics as defined units of competency in the engineering Advanced Diplomas defined in Training Packages is an ongoing academic concern for articulation, given the strong emphasis in the first two years of most engineering degrees. A lack of mathematical ability (especially calculus) can greatly inhibit progress in other underpinning science and basic engineering courses, a topic developed further in the attrition theme of the ALTC project (Godfrey & King, 2011)

One outcome of the lack of mathematics in VET qualifications is that articulating students may have their allowed enrolment split across program years, and potentially fragmented timetables: they may feel that they are playing 'catch-up', and never quite have the pre-requisite knowledge for their courses. The RMIT solution to this is to include the required mathematics in the Advanced Diploma curriculum, at least for those students aspiring to articulate to the degree. A similar approach is taken at the University of Southern Queensland for those Associate Degree students who plan to articulate to the degree. Swinburne has taken similar steps to include mathematics in their VET programs to the level of first-year university mathematics. A supporting measure is to provide diagnostic assessment of mathematics capability and provide appropriate bridging courses, although this requires further resources.

The focus groups also raised the broader question of what mathematics is 'really required' for engineering; some participants (and others) argue that civil engineers do not use (and therefore require) as much advanced mathematics as, say, electrical and chemical engineers. Further discussion of this topic is, however, well beyond the scope of this study.

4.3.4 The growth of Associate Degrees with alternative goals, but at the same AQF Level as Advanced Diplomas is a recipe for confusion

As reported earlier, Engineers Australia has developed accreditation processes for both curriculum-based Associate Degrees and competency-based Advanced Diplomas programs for the Engineering Associate occupation and has recently applied for membership of the Dublin Accord. The name of this occupation is not uniform: internationally the occupation is referred to as 'Engineering Technician', while Australia uses the names Engineering Officer, Engineering Associate and paraprofessional for the role. Until recently, Advanced Diplomas (and their precursors) were the normal qualification route into that occupation, but Engineers Australia did not operate a formal professional accreditation system for these programs until 2009.

The recent growth of Associate Degrees provided by both the VET and the higher education sectors, is leading to Associate Degree qualifications of two types: those that lead to an accredited qualification for entry to the recognised occupation of Engineering Associate; and those that are pathways to bachelors degrees. Both outcomes are legitimate within the AQF Level 6 specification, which is also the level for the Advanced Diploma. The earlier discussion of articulation at RMIT implies that the Associate Degree is becoming a more desirable qualification for prospective students, than the Advanced Diploma.

Whilst all this can be ***explained***, it is not surprising that employers, prospective students and academics and teachers may be confused about the different awards, their names and purposes, and how they fit together. The potential value of the Engineering Technologist occupation, supported by well-focussed three year degrees appears lost in the confusion.

One of the reasons for the growth of the Associate Degrees is that VET providers value being able to design curricula to meet local needs, and determine their assessment. The providers of these higher education qualifications are not, as in the case of the national VET Diploma and Advanced Diplomas, bound by the Industry Skills Councils or the VET administration and reporting systems.

On the other hand, employers that are closely linked to the ISCs reported that, while they continue to value the vocationally oriented qualifications, they are concerned about the decline in their enrolments especially as they have great difficulty in replacing retiring staff who were trained decades ago though the precursors of the Advanced Diploma awards.

Thus, prospective students are faced with an almost bewildering choice if they seek to be 'engineers' but do not have the motivation or academic background to enter directly into a bachelors degree. Contemporary societal and family expectations tend to favour entry to university degrees, and the growth of Foundation Programs and Associate Degrees is a response to that pressure. But faced with choosing between the several options and pathways into engineering, some prospective students may decide to do something else altogether, and engineering misses out.

4.3.5 Lack of provision of VET Advanced Diplomas in all states

The lack of provision of VET Advanced Diplomas in all engineering disciplines and in of all states and territories, limits the pool of prospective students for articulation. This issue was discussed by Dowling (2010a). These awards are generally confined to metropolitan TAFEs, yet much of Australia's engineering in infrastructure and resource projects takes place in regional areas, while many employees work on fly-in-fly-out schedules.

In the engineering-related areas the regional VET institutes offer mainly trade qualifications at AQF Levels 3 and 4. It would appear to be advantageous to increase the provision of higher level engineering awards in these VET institutions to provide a stronger supply of paraprofessionals and, in time, more enrolments in degree programs. Government policy supports training in skills areas, but this is of no value if the higher level awards are not available due to low student numbers and limited capital and human resources in regional institutions.

4.3.6 Changing characteristics of articulating students and their aspirations

Before the privatisation of national engineering infrastructure from the late 1980s, most of the students articulating from VET awards would have had work experience and a strong understanding of their industry. This understanding and experience went some way to compensating for some of their gaps in academic background. They were also likely to have some employer sponsorship and support. Current mature students seeking to upskill via conventional higher education pathways face much higher financial penalties, especially for full-time study. On the other hand, there may well be more support in the form of bridging programs to assist their transition to study.

Today, fewer VET students have such work experience and employer support as more of them study full-time on campus and plan to uses their advanced diploma awards as pathways to higher education, particularly in dual-sector institutions. For example, Dowling (2010b) found that only 26 per cent of the Diploma students and 31 percent of the Advanced Diploma students who completed the online questionnaire were working in the engineering industry during their studies.

As described earlier, more students are taking associate degrees that are designed for both occupation and pathway outcomes, both in dual-sector institutions and in the distance education offers of university programs. Their aspirations to articulate to degrees were substantiated by a recent study (Dowling 2010b), reported in the following terms:

> "*During the period 2006-2008 there was a large and unexpected growth in the commencing enrolments in the distance education offer of the Associate Degree in Engineering program at USQ, with the commencing student total growing from 115 in 2005, to 337 in 2008. A small questionnaire was developed in 2006 to explore the reasons for this spike in enrolments, and to gather information about these students, who mostly study part-time because they work full-time in the engineering industry.*
>
> *A preliminary analysis of 247 responses found that 63% of the students have a career goal to become a Professional Engineer and see the Associate Degree as a stepping stone to the Bachelor of Engineering. Surprisingly, only 14% of the respondents intend to pursue a career as an Engineering Associate.*

The study was widened in 2010 to include students studying paraprofessional engineering programs at other universities, dual sector universities and VET institutions. The study reported that the findings of the earlier study were replicated at the national level (Dowling 2010b):

> "*The paper reports on a preliminary analysis of some of the raw data from 327 engineering students, 40% of whom are studying an Associate Degree course, 45% an Advanced Diploma, and 15% a Diploma. The key finding was that only 16% of the respondents intend to pursue a career as an Engineering Associate, with 75% indicating that they plan to undertake further studies, and 51% reporting that they have a career goal to become a Professional Engineer. These unexpected results challenge a long-held assumption that students in Australian Advanced Diploma and Associate Degree programs will pursue careers as Engineering Associates".*

These findings reinforce the view expressed earlier on the societal trends towards higher education. There are clearly ***real challenges*** for tertiary engineering as a whole to supply the range of engineering expertise required in the industries and locations where they are needed.

4.3.7 Recognition of workplace learning

Students in Diploma and Advanced Diploma programs are able to apply for the recognition of prior learning (RPL) based on prior studies or their workplace experience. In fact, the current VET system is based on the premise that much of a student's training will occur in the workplace which is formally assessed by a VET assessor in the student's workplace.

The option of having **prior** workplace learning assessed is not widely available in the university sector, where credit is normally only given for prior studies. There are some exceptions, for example where students are able to submit a portfolio of their work to demonstrate the application of equivalent knowledge and skills.

One reason for the low take-up of RPL for prior workplace learning in the university sector is that current funding arrangements do not allow universities to charge a fee for what can be a time consuming assessment process. Another reason is that, unlike VET teaching staff, university academic staff are unlikely to have undertaken the formal training generally required to be able to easily and efficiently complete this type of assessment, for example a Certificate IV in Training and Assessment. A third reason is that an increasing majority of university staff have no industry experience, having followed a research path, and consequently they can find it difficult to relate to the industry experiences being described during the assessment process.

5 Recommendations on Improving the Provision and Operation of Pathways from VET qualifications in engineering

There is clearly a growing body of experience amongst the higher education engineering providers in running a wide range of pathway programs, and a good understanding of the factors that inhibit their ability to increase the numbers of engineering graduates at all levels. There is also increasing diversity of provision: as noted earlier more VET institutions are likely to offer Associate Degree programs in engineering, and at least one in moving into offering three-year engineering technology degrees.

The growth of pathways does not of itself increase the number of students taking them. The underlying concern of the engineering academic and professional community is that domestic student growth is limited fundamentally by the number of school-leavers and others seeking careers in engineering at either the Professional Engineer or other levels. Further studies and initiatives in this area will continue to be important to promote engineering and prepare a larger proportion of the population for engineering work, as recommended in the review of engineering education (King, 2008).

This section discusses what engineering educators can do to ensure the best outcomes for students following pathways from VET qualifications, drawing on evidence of practice, particularly from the collaborating partners in the recent study (Godfrey & King, 2011: 164-173). This section of the report therefore draws on and elaborates relevant parts of that report[17], and includes most of its recommendations on improving pathway effectiveness.

The linked structure of occupations and qualification specifications within the engineering profession should make cross-sector articulation a reasonable, accessible and efficient outcome for a proportion of VET Diploma and Advanced Diploma students. Paradoxically perhaps, during the past two decades while the sectors have converged in some respects, they have diverged in others, leading to some of the barriers discussed earlier. For the purposes of the present discussion it is useful to classify a hierarchy of cross-sector articulation models, as shown in Table 11, each with its own exemplars of good practice. At the first level, a higher education institution simply accepts and assesses applications; at the second and later levels the partner institutions operate with progressively more formal and closer relationships . The characteristics of each partnership will necessarily depend on circumstances and the goals of the partners, and will be influenced by funding, regulatory and course requirements, location, and occupational and industrial standards.

One of the key points of difference between the two sectors is that the VET Training Packages that specify the competencies for most Diplomas and Advanced Diplomas are overseen by separate (divergent) Industry Skills Councils, whereas the higher education qualifications are generally overseen institutionally by (convergent) engineering faculties that cover all disciplines and influenced nationally by the (generic) accreditation requirement of the professional body, Engineers Australia. To move forward, the ALTC report recommended a collaboration that

[17] That report also included discussion of pathways entirely within the higher education sector, including from Associate Degrees and Foundation Programs, and graduate entry masters programs, all of which are increasing in number and many of which are aimed supporting participation of lower SES students, and to meet the educational needs of regional communities.

could well be led by the Australian National Engineering Taskforce.

Recommendation 1: The Australian Council of Engineering Deans should establish a national dialogue between the five engineering related Industry Skills Councils and Skills Australia, VET and higher education, and Engineers Australia, to ensure that Diplomas and Advanced Diplomas defined in training packages are meeting adequately the occupational needs of all the engineering industries, are aligned with the accreditation standard, and provide efficient pathways for students aspiring to articulate to higher level qualifications.

The following sections present recommendations to reduce the barriers to successful pathway operation in more specific areas, based on evidence of good practice.

Table 11 Articulation models between the VET and HE sectors, with partnership characteristics and exemplars (based on Godfrey & King, 2011)

Articulation Model	Partnership Characteristics	Exemplar
Sequencing of qualification (No guaranteed enrolment)	Separate institutions operate in their respective sectors. Separate funding and regulatory regimes. Variable credit transfer.	None: this model is used by most HEd providers with case-by-case assessment of credit
Sequencing of qualification (guaranteed enrolment)	As above plus: more established relationship and agreement between institutions. Aligned subjects allow block credit.	TAFESA Associate Degree to University of Adelaide (see Section 3.3) Holmsglen TAFE (Advanced Diploma) to University of Ballarat degree
Joint enrolment (dual-offer) in sequential qualifications	Similar to above plus: co-location to draw on similar cohort of student or metropolitan –regional collaboration to expand options Requires: formal MOU; qualification alignment; confidence in quality of teaching standards of the respective institutions.	SBIT Associate Degree to QUT and USQ degree (see Section 3.3) Australian National University and Canberra Institute of Technology Associate Degree
Dual sector institution with integrated service across multiple awards	Dual-sector institution offers VET and HE qualifications, with access to both funding streams.	RMIT, Swinburne (see Sections 3.3 and 4.1)

5.1 Cross-sector relationships for supporting articulation

Good working relationships between universities and VET providers clearly benefit articulation between their qualifications, as best exemplified by the dual-sector partners described earlier. Close relationships can strengthen the pathways into university, broaden student learning experiences, ease students' transition, and improve their success. In some cases partnerships can foster alternative specific routes to university for low SES students and improve their participation. Like all partnerships however, their success depends on commitment of purpose and mutual benefit, respect and trust, strong relationships between the staff of the participating institutions, and flexibility. They need to be backed up by good systems and services that allow university staff to manage pathways and students to navigate them. They should be institutional, and not dependent on the particular interests of individuals.

Recommendation 2: Build strong relationships between TAFE institutes and universities based on clear goals and well-defined articulation models.

The models of articulation and examples cited in Table 11 demonstrate that there is knowledge and experience amongst stakeholders to develop such relationships.

5.2 Curriculum and credit mapping: towards optimal design of pathway programs

A goal of a formal partnership is to systematically improve the success of VET students in university study. In short, it should improve articulating students' abilities to deal with the conceptual, research and analytical skills in a degree, or improve the vocational content of a lower level award. Clearly, the VET Advanced Diplomas contain much lower levels of mathematics and fundamental science than the first two years of the bachelors' degrees.

Given the similarities between first year curricula in engineering degrees (especially in mathematics and science) and the fact they are delivered in full-time on-campus mode by all universities, it might be expected that HEd providers would offer similar amounts of credit to VET Advanced Diplomas, and operate similar bridging programs to cover the gaps.

In reality, perhaps because of the relatively small numbers of articulating students, and the individuality of the Advanced Diplomas, each provider tends to develop their own credit database and has to consider applicants individually. There would appear to merit in developing a national approach to determining the core gaps between the nationally provided VET Advanced Diplomas and the first two years of typical engineering degrees, and take into account the provisions of the AQF credit transfer guidelines. This approach would, in the first instance, build on the operational experience of each HEd provider.

Recommendation 3: Systematise experience of granting credit and defining bridging into engineering degrees to establish a map of the curriculum gaps between VET advanced diplomas and their own programs, and share this towards providing a national resource.

All participating institutions in the ALTC study agreed that such a national resource would be desirable, and envisaged that it could be developed and maintained under the auspices of TEQSA.

Deeper understanding of the curriculum and educational interfaces between the VET awards and the engineering degrees would provide a stronger platform for VET providers to develop and deliver specific Advanced Diplomas (and other awards) that maximise articulation credit, minimize the need for bridging courses, and maintain the current funding benefits for the VET institutions and their students. The benefits include having such programs designated as 'training' to attract the current employer incentives.

Recommendation 4: Build on current relationships to negotiate Advanced Diplomas as optimum articulation streams into engineering degrees and as valued employee training.

Similarly, more Associate Degrees could achieve good occupational outcomes through VET-university partnerships, perhaps with industry support. The program would be co-designed by the partners, and would include the required level of foundation mathematics and physics for articulation to a higher level award, and strong occupational outcomes with subjects provided by VET. However, it is apparent that several institutions have decided not to do this and offer pathway programs purely designed to articulate into a BEng.

Recommendation 5: Use partnerships for joint development of Associate Degrees with strong articulation and occupational outcomes.

5.3 Improve bridging and support processes for articulating students

VET qualified entrants to university studies in engineering are usually well motivated, but often lack the academic background of school-leavers. Most universities have established additional support to engineering students, most often in early year mathematics and university study-skills. A challenge for curriculum design is to ensure that these students can indeed 'catch-up' to their peers, without the disadvantages of overloading what are usually regarded as quite heavy timetables. Many universities offer summer semester study in core subjects to assist such students, and an alternative approach would be to offer or recommend bridging material on-line. The Open Learning Australia (OLA) offers the first-year University of Southern Queensland mathematics course for this purpose, and also offers its Tertiary Preparation Program[18] by distance education. It would also be possible, under a partnership scheme, to have VET institutions provide some of the bridging material, and thereby serve the interests of several universities, with corresponding cost efficiencies.

Recommendation 6: Develop methodologies, including diagnostic testing, to ensure students needing additional support are identified early and encouraged to take the required bridging courses and use the additional support available. This may require development of more systematic (proactive) processes between the engineering schools and university-provided support systems.

Recommendation 7: Identify core areas in which bridging courses are required and determine the optimum ways of delivering them, including via partnerships with other universities, VET institutions, and via distance education and on-line provision.

Such provision needs to be vigorously advertised on: governments' career advice and education websites; by Engineers Australia; APESMA; and individual companies. The engineering qualifications could be listed by outcome (eg pathway, occupation etc.). The key role that program accreditation by Engineers Australia plays at all occupational levels must be reinforced. In particular, promotion of the internationally benchmark for the qualifications leading to Engineering Associate occupations is necessary. Engineering schools in VET and HEd need to be encouraged to clearly advertise the outcomes of their programs, and to use program and award titles that are clear in terms of their level, purpose and broad discipline area.

Recommendation 8: Advertise more widely (including via Engineers Australia) the availability of recognised bridging and foundation courses to encourage prospective students who do not meet the requirements for direct admission into engineering degrees.

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[18] See http://www.usq.edu.au/future-students/am-i-eligible/pathways

5.4 Increasing the flexibility of engineering curricula to attract and retain more students

A key recommendation to overcome the skills crisis could be that the government should support employers who offer traineeships or cadetships that enable students to study AQF Level 6 (Advanced Diploma or Associate Degree) programs part-time, either on-campus or by distance education. While the majority of them live and work in metropolitan and regional areas of Queensland and New South Wales, others come from all of the remaining states and territories.

Clearly there are many pathways into and within Australian engineering degrees and many systems for supporting students to graduate from them. But there are fewer students graduating from engineering than the nation requires. The reasons for the lack of student demand are complex and have been studied in Australia and elsewhere in the industrially developed world.

Discussion of curriculum change in engineering degrees that might significantly increase (transform) its position in the rankings of preferred tertiary study (and increase its attraction to women) is beyond the scope of this study. Nevertheless, these are relevant issues, and they were explored in the ALTC study, and recommendations made in three areas, as some could best be pursued in partnerships between VET and university providers. The issues are summarised below, together with the recommendations.

Firstly, there is a net loss of students from engineering degrees into other areas, both before confirmation of acceptance of an offer, and after program commencement. The image (and reality) of engineering degrees as being very hard and highly structured, may deter more prospective students than the discipline deserves. While the introduction of more problem-based learning and design into the early years of the curriculum, together with much stronger emphasis on the broad and humanitarian purposes of engineering[19], as well as its very strong position in the graduate salary rankings, have the potential to assist in reversing the apparently negative perceptions in which it is held, there is much more to be done.

Recommendation 9: Examine engineering curricula to minimise the barriers to students with aptitude for engineering and interests in design and business to enter or transfer into engineering.

The university engineering schools do not generally support withdrawing students by providing them with information on Level 6 qualifications and pathways. Some may be well motivated to pursue engineering at a lower occupational level. This could stem the loss of these people from the engineering industry.

Recommendation 10: Develop an information pack (online and printed) that can be distributed to withdrawing engineering students that provides advice about programs and careers at the Associate Engineer level.

A further specific group that needs to be supported by suitable education packages are the overseas trained engineers, who are admitted to Australia on priority visas to redress the skills shortage, but who find it difficult to gain employment. Projects established by Engineers

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[19] Mr Merv Lindsay, National President of Engineers Australia 2010-11, made this point in an interview reported in Engineers Australia Magazine, November 2010. Engineers Australia has declared 2011 the Year of Humanitarian Engineering.

Australia in collaboration with TAFE institutes to provide contextualised training and work experience have assisted this group to enter the Australian workforce. Engineers Australia also supported the development of a resource for immigrant engineers (Little, 2009). However, these programs have been available to only small numbers, and there are clearly many disgruntled ex-engineers working as taxi drivers and other roles in the community.

VET providers in Victoria offer several retraining programs, within the Employment Development Program for overseas professionals. These include development of professional English language skills in an 11 week unit which runs four times a year. This course is suitable for overseas trained engineers, other technical professionals, and business professionals. It focuses on developing students' workplace English, communication skills and provides knowledge of the practices within a technical and professional work environment, in Australia. The course aims to teach overseas-born professionals to successfully navigate the job market and to transfer their experience and skills to the local workplace. Another successful initiative in Queensland in 2008 was a 4 month full-time work experience program for overseas qualified engineers run by Brisbane North TAFE.

Recommendation 11: Continue to work with Engineers Australia and others to provide short courses and other programs that can assist immigrant engineers to assimilate into the workforce.

The third area of potential activity for education providers is to support retraining and upskilling of working engineers (including para-professionals), particularly to meet state development goals. Much of this is likely to be achieved by short courses in specific areas, and some individuals will seek higher education pathways. The disincentives for undertaking such programs as these are financial, unless employer-sponsored, and time, especially for full-time employees. Program flexibility, as discussed later is also an issue. Clearly for such students, any bridging courses need to be identified and made available in the most suitable delivery mode.

Recommendation 12: Institutions offering higher education awards should work proactively with state development agencies and others [including VET institutions] to provide short courses to address specific skills shortages that may inhibit infrastructure and other development.

5.5 Increasing the availability of part-time and flexible study patterns

The lack of flexibility of engineering curricula was cited by several students surveyed in the ALTC study (Godfrey & King, 2011) as a major drawback to their studies. VET qualified students, as noted earlier, are likely to be taking their degree part-time, and be fully employed. The focus groups reported that even for universities with large proportions of part-time students, there are insufficient facilities and staff for sensible timetables. As a result, more and more and more students are not attending lectures. Suggestions from students included more blocking of timetables, and the possibility of cheap overnight near-campus accommodation.

Recommendation 13: Higher education providers with large part-time enrolments should examine the provision of classes to meet their needs more favourably.

This is compensated for in some universities by recording lectures and in all universities by having all course materials on websites, and encouraging the use of interactive software. Only two universities, the University of Southern Queensland and CQ University, offer all their undergraduate engineering programs by distance education. Both require students to attend laboratory classes in block mode on campus during each year. Other providers may offer some of their courses in that mode. It was noted that engineering has only a small presence in Open Universities Australia.

There would appear to be increasing potential for more education providers to deliver more of their programs to more students by distance mode, especially those employed in the regions. Advances in educational technologies will surely support this direction, noting that already there is a major consortium, *LabShare*, developing the capacity for operating remote laboratory experiments (LabShare, 2010) suitable for students in secondary, as well as tertiary education.

It would be impractical and inefficient for all VET and HEd providers to formally develop their programs for full distance mode. There would be value, however, for consortia of universities to jointly develop core and specialised courses for such delivery and cross-accredit them in their programs. The need for on-campus laboratory and project work in engineering would suggest that each state should have at least one such provider (for both VET and HEd award programs), in a major city. Such joint development and materials sharing is also consistent with the development of best-practice in engineering education, as proposed in Recommendation 3 of the 2008 review (King, 2008).

Recommendation 14: Scope partnerships (between HEd providers and between HEd and VET) to deliver more of pathway and engineering programs by distance mode.

5.6 Roles for industry to support pathways and articulating students

The 2008 review (King, 2008) included a number of examples of industry support for students and programs and Recommendation 5 proposed a number of actions to increase the authenticity of engineering education through industry engagement. Despite the challenges of the global financial crisis many engineering companies have continued to provide support scholarships to engineering degree students. These are valued by the students, universities and employers, and can be vital incentives for low SES and regional students to enter tertiary education. Cadetships that combine part-time work with study over most or all of the study period provide financial and employment stability: their provision may need to be extended as a strategy for growing the engineering workforce. Anecdotal evidence suggests that advertised cadetships often attract applications from people who had never considered engineering as a career. Some regional employers have also reported that they have had no responses to their advertisements for Engineering Associate cadetships. Dowling (2010b) also reported that an increase in industry cadetships was one of the main drivers for a rapid increase in enrolments in the distance education offer of the USQ Associate degree in Engineering during the period 2006-2008.

The recent study reported that a number of companies and industries are re-introducing higher education cadetships, motivated by prospective shortages in their engineering workforce. Examples of support cited for both para-professional and degree studies included Energy Australia, and for Associate Degrees, OneSteel, and the defence industry in South Australia (Godfrey & King, 2011: 173).

These examples illustrate the problems of specific skills shortages in regional locations and in key industries, and the value of partnerships to meeting the needs. While the higher education providers are usually receptive to structuring programs around needs, very often the prospective numbers turn out to be too small for program viability, particularly in the longer term. Industry consortia, such as the Australian Power Institute and the Minerals Tertiary Education Council have been invaluable in supporting university consortia to provide viable and nationwide education programs to serve their needs. This concept needs to be extended as widely as possible to attract and support students who might not otherwise consider taking engineering. Many of these issues have also been taken up by the National Resources Sector Employment Taskforce, and are largely supported by government (NRSET, 2011).

Recommendation 15: education providers [in both sectors] should use their industry advisory bodies and educational and community networks to identify pathway programs to address skills shortages, and additional mechanisms, such as cadetships to support students.

6 Conclusions

This review of the provision and operation of pathways from VET qualifications into engineering degrees has reported from a higher education perspective. The engineering degree programs are taken to be the 'target' for articulating students. The prime VET qualifications programs of interest, as the source qualification for articulating students, are the Diplomas and Associate Diplomas, formulated as competency-based national Training Package qualifications or institutionally developed Accredited Courses.

The recent growth of Associate Degrees (as curriculum-based higher education qualifications that may be offered by both VET institutions and universities, and mostly aimed at supporting their graduates to articulate into degrees) has added a new dimension into the qualification and articulation picture for engineering. These programs appear to be displacing the provision (and take-up) of Advanced Diplomas and Diplomas that had a prime focus on occupational outcomes at the paraprofessional level.

The number of graduates from Advanced Diplomas across the engineering disciplines seems barely adequate to satisfy both occupational employment demands and a growing cohort of students that aspire to articulate into engineering degrees.

Incorporating the findings of prior work by the authors and others, the study has reported on examples of good practice in operating pathways between the sectors, and made recommendations to share best practice in key areas, including the assessment of credit transfer more efficiently. Not surprisingly, the dual-sector providers in Victoria provide most of the examples of effective pathway operation. Their key operational features could, however, be emulated in jurisdictions without dual-sector institutions.

The evidence is that the rate of progression and success of VET-qualified entrants in their degree studies is poor, and that the engineering schools in the higher education could take measures to improve both their programs and academic support to increase these students' graduation rates. Accordingly, recommendations to progress these measures are made, noting that such actions would be likely to benefit all degree students, and increase the overall graduation rates.

A possible mechanism for strengthening articulation pathways, and enhancing the attrition rates of articulating students, would be to develop some Level 5 and Level 6 qualifications to be a blend of VET competency-based course and HE curriculum based courses. RMIT uses this approach in its AQF Level 6 engineering programs.

The premise underlying this study is that the number of engineering degree graduates can be increased significantly by improving the provision of pathways from VET qualifications. The conclusion from the data and evidence examined is that such growth is most likely to arise from Associate Degree pathways operated by both VET and HEd institutions, rather than from the competency-based Diplomas and Advanced Diplomas.

Assuming that the latter qualifications are well directed to industries' needs, every effort should be taken to increase their enrolments, along with those in Associate Degrees. Broad and informed industry, education and professional perspectives need to be developed on the focus and additional support of all such programs, if Australia is to provide the desired balance of engineering qualified professionals and paraprofessionals.

References

ARC (2011), *ERA 2010 National Report*. Commonwealth of Australia. Accessed at www.arc.au/era/

ANET (2010), *Scoping the Future*, Australian National Engineering Taskforce. Accessed 7 April 2011 at http://www.anet.org.au/wp-content/uploads/2010/12/Scoping-our-futureWEB.pdf

AQF (2007), *National Guidelines on Cross-sector Qualification Linkages*. Accessed on 16 Nov 2010 at http://www.aqf.edu.au/Portals/0/Documents/Handbook/ AQF_Handbook_07.pdf

AQF (2010), *The Australian Qualifications Framework*. Accessed 7 April 2011 at http://www.aqf.edu.au/Portals/0/Documents/Australian%20Qualifications%20Framework%202011%20approved%20by%20MCTEE%2018%20March%202011.pdf

Bradley, D., Noonan P., Nugent, H., & Scales, W. (2008). *Review of Higher Education: Final Report.* Department of Education, Employment and Workplace Relations, Canberra.

DEEWR (2008)

DEEWR (2010a) Higher Education Student Collection. DEEWR, Canberra. Accessed on 17 November 2010 at http://www.heimshelp.deewr.gov.au/11_HE_Student_Data_Collection/

DEEWR (2010b) Undergraduate Applications, Offers and Acceptances, 2009. DEEWR Canberra. Accessed on 17 November 2010 at http://www.deewr.gov.au/HigherEducation/Publications/HEReports/Documents/FINALAppsandOffers2009.pdf

DEEWR (2010c) Base Funding Review, http://www.deewr.gov.au/HigherEducation/Policy/Pages/BaseFundingReview.aspx

Dowling, D. (2011), A review of engineering technician education in Australia: Programs, pathways and perspectives, *Your Passport to Engineering Education*, 118th ASEE Annual Conference &. Exposition, June 2011, Vancouver, Canada (Accepted)

Dowling, D. (2010a), A review of para-professional engineering education in Australia: Exploring the VET and HE divide. AAEE2010, Sydney

Dowling, D. (2010b), The career aspirations of a cohort of Associate Degree students: Implications for the engineering profession. AAEE2010, Sydney

Engineers Australia (2011a), Accredited Programs [for each occupational level]. Updated 21 February 2011, and accessed on 18 March 2011 from http://www.engineersaustralia.org.au/about-us/program-accreditation/program-accreditation_home.cfm

Engineers Australia (2011b), *Revised Stage 1 National Competency Standards*. Accessed 4 April 2011 from http://www.engineersaustralia.org.au/about-us/program-accreditation/program-accreditation_home.cfm

Engineers Australia (2011c), *Guidelines for Accredited Masters Programs*. Accessed 4 April from http://www.engineersaustralia.org.au/about-us/program-accreditation/program-accreditation_home.cfm

Godfrey, E., & King, R. (2011). *Curriculum Specification and Support for Engineering Eduaction: understanding attrition, academic support, revised competencies, pathways and access.* Accessed 23 March 2011 at http://www.altc.edu.au/resource-engineering-qualification-curriculum-uts-2011

IEA (2009), *Graduate Attributes and Professional Competencies (version 2)*, International Engineering Alliance. Accessed on 16 Nov 2010 at http://www.washingtonaccord.org/IEA-Grad-Attr-Prof-Competencies-v2.pdf

ICEWaRM (2008). *National Water Skills Audit.* A commissioned report for the Council of Australian Governments, accessed on 18 March 2011 at http://www.awa.asn.au/uploadedFiles/Content/Programs_and_Networks/Industry_Programs_docs/National_Water_Skills_Strategy_Business_Plan/National%20Water%20Skills%20Audit_low%20res%20(2).pdf

King, R.(2008) *Engineers for the future: addressing the supply and quality of engineering graduates for the 21st century*, Australian Council of Engineering Deans. Accessed 17 November 2010 from http://www.engineersaustralia.org.au/aced/about-us/about-us_home.cfm

Little, I. (2009), *Project Australia: land that Engineering job in Australia.* EA Books: Sydney

Lloyd B E, Stokes R, Rice M R, and Roebuck W N (1989)*, New pathways in Engineering Education*, Histec Publications, Melbourne

Lowry, D, Molloy, S, Tan Y 2006, *The Labour Force Outlook in the Minerals Resources Sector: 2005 to 2015*, commissioned report prepared by National Institute of Labour Studies, Flinders University, for the Minerals Industry National Skills Shortage Strategy

NCVER, 2009. *Students & Courses.* Australian vocational education and training statistics, NCVER on behalf of DEEWR. See www.ncver.edu.au

NQC, 2009, Vet products for the 21st century, Final Report of the Joint Steering Committee of the NQC and the COAG Skills and Workforce Development Subgroup, National Quality Council, June 2009, accessed on 30 March 2011 at ttp://www.nqc.tvetaustralia.com.au/__data/assets/pdf_file/0004/49657/VET_Products_for_the_21st_Century_-_FINAL_REPORT.pdf

Ohland, M. W., Sheppard, S. D., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. A. (2008). Persistence, engagement and migration in engineering programs. Journal of Engineering Education, 97(3), 259-278.

Shreeve, R (2010, Creating a future direction for Australian vocational education and training - discussion paper, Skills Australia. Accessed 4 April 2011 at http://www.skillsaustralia.gov.au/PDFs_RTFs/discussionpaperdirectionforVET.pdf

Thompson, P (2010), *Design and Technology Education in Australian Schools.* Invited address to the Australian Council of Engineering Deans, Adelaide

Watson L and McIntyre J (2011) *Scaling Up; Building engineering workforce capacity through education and training.* ANET March.

Wheelahan, L, Moody, G, Billet, S, Kelly, A (2009), *Higher Education in TAFE,* NCVER, Adelaide.

Appendix 1 Engineers Australia's role descriptions of engineering occupations

These statements characterise the senior practice role that a mature practitioner may be expected to fulfil. Extracted from the *Engineers Australia - Chartered Status Handbook.*

THE MATURE PROFESSIONAL ENGINEER

Professional Engineers are required to take responsibility for engineering projects and programs in the most far-reaching sense. This includes the reliable functioning of all materials, components, sub-systems and technologies used; their integration to form a complete, sustainable and self-consistent system; and all interactions between the technical system and the context within which it functions. The latter includes understanding the requirements of clients, wide ranging stakeholders and of society as a whole; working to optimise social, environmental and economic outcomes over the full lifetime of the engineering product or program; interacting effectively with other disciplines, professions and people; and ensuring that the engineering contribution is properly integrated into the totality of the undertaking. Professional Engineers are responsible for interpreting technological possibilities to society, business and government; and for ensuring as far as possible that policy decisions are properly informed by such possibilities and consequences, and that costs, risks and limitations are properly understood as the desirable outcomes.

Professional Engineers are responsible for bringing knowledge to bear from multiple sources to develop solutions to complex problems and issues, for ensuring that technical and non-technical considerations are properly integrated, and for managing risk as well as sustainability issues. While the outcomes of engineering have physical forms, the work of Professional Engineers is predominantly intellectual in nature. In a technical sense, Professional Engineers are primarily concerned with the advancement of technologies and with the development of new technologies and their applications through innovation, creativity and change. Professional Engineers may conduct research concerned with advancing the science of engineering and with developing new principles and technologies within a broad engineering discipline. Alternatively, they may contribute to continual improvement in the practice of engineering, and in devising and updating the codes and standards that govern it.

Professional Engineers have a particular responsibility for ensuring that all aspects of a project are soundly based in theory and fundamental principle, and for understanding clearly how new developments relate to established practice and experience and to other disciplines with which they may interact. One hallmark of a professional is the capacity to break new ground in an informed, responsible and sustainable fashion.

Professional Engineers may lead or manage teams appropriate to these activit7ies, and may establish their own companies or move into senior management roles in engineering and related enterprises.

THE MATURE ENGINEERING TECHNOLOGIST

Engineering Technologists normally operate within broadly defined technical environments, and undertake a wide range of functions and responsibilities. They are often specialists in the theory and practice of a particular branch of engineering technology or engineering-related technology (the technology domain), and specifically in its application, adaptation or management, in a variety of contexts. Their expertise often lies in familiarity with the current state of development of a technology domain and most recent applications of the technology. Within their specialist field, their expertise may be at a high level, and fully equivalent to that of a Professional Engineer. Engineering Technologists may not however, be expected to exercise the same breadth of perspective as Professional Engineers, or carry the same wide-ranging responsibilities for stakeholder interactions, for system integration, and for synthesising overall approaches to complex situations and complex engineering problems.

The work of Engineering Technologists combines the need for a strong understanding of practical situations and applications, with the intellectual challenge of keeping abreast of leading-edge developments as a specialist in a technology domain and how these relate to established practice. For this purpose Engineering Technologists need a strong understanding of scientific and engineering principles and a well developed capacity for analysis. The work of Engineering Technologists is most often concerned with applying current and emerging technologies, often in new contexts; or with the application of established principles in the development of new practice. They may also contribute to the advancement of technology.

Engineering Technologists frequently will take responsibility for engineering projects, services, functions and facilities within a technology domain, for specific interactions with other aspects of an overall operating context and for managing the contributions of their specialist work to a broader engineering system or solution. In these roles, Engineering Technologists must focus on sustainable solutions and practices which optimise technical, social, environmental and economic outcomes within the technology domain and over a whole systems life cycle. They will have an intimate understanding of the standards and codes of practice that underpin the technology domain and ensure that technology outcomes comply with statutory requirements. Engineering Technologists are required to interact effectively with Professional Engineers and Engineering Associates, with other professionals, tradespersons, clients, stakeholders and society in general, to ensure that technology outcomes and developments fully integrate with the overall system and context.

Engineering Technologists must ensure that all aspects of a technological product, or operation are soundly based in theory and fundamental principle. They must understand how new developments relate to their specific field of expertise. They will be often required to interpret technological possibilities, to investigate interfaces, limitations, consequences, costs and risks.

Engineering Technologists may lead teams responsible for the implementation, operation, quality assurance, safety, management, and maintenance of projects, plant, facilities, or processes within specialist practice area(s) of the technology domain. Some Engineering Technologists may establish their own companies or may move into senior management roles in engineering and related enterprises, employing Professional Engineers and other specialists where appropriate.

THE MATURE ENGINEERING ASSOCIATE

Engineering Associates have a wide range of functions within engineering enterprises and engineering teams. Examples of their roles may include feasibility investigation, scoping, establishing criteria/performance measures, assessing and reporting technical and procedural options; design and development; component, resources and materials sourcing and procurement; construction, prototyping, manufacture, testing, installation, commissioning, service provision and de-commissioning; tools, plant, equipment and facilities acquisition, management, maintenance, calibration and upgrades; operations management; procedures documentation; presentation and reporting; maintenance systems design and management; project and facility management; quality assurance, costing and budget management; document control and quality assurance.

Engineering Associates are often required to be closely familiar with standards and codes of practice, and to become expert in their interpretation and application to a wide variety of situations. Many develop very extensive experience of practical installations, and may well be more knowledgeable than Professional Engineers or Engineering Technologists on detailed aspects of plant and equipment that can contribute very greatly to safety, cost or effectiveness in operation.

In other instances, Engineering Associates may develop high levels of expertise in aspects of design and development processes. These might include, for example, the use of advanced software to perform detailed design of structures, mechanical components and systems, manufacturing or process plant, electrical and electronic equipment, information and communications systems, and so on. Other examples might be in the construction of experimental or prototype equipment. Again, experienced operators in these areas often develop detailed practical knowledge and experience complementing the broader or more theoretical knowledge of others.

Engineering Associates need a good grounding in engineering science and the principles underlying their field of expertise, to ensure that their knowledge and skills are portable across different applications and situations within the broad field of practice. Equipment, vendor or context-specific training in a particular job are not sufficient to guarantee generic competency. Given a good knowledge base, however, Engineering Associates may build further on this through high levels of training in particular contexts and in relation to particular equipment. Aircraft maintenance is an excellent example.

The competencies of Engineering Associates equip them to certify the quality of engineering work and the condition of equipment and systems in defined circumstances, laid down in recognised standards and codes of practice.

Engineering Associates may lead or manage teams appropriate to these activities. Some may establish their own companies or may move into senior management roles in engineering and related enterprises, employing Professional Engineers, Engineering Technologists, and other specialists where appropriate. In Australia, the term ‘para-professional' is frequently used to describe the Engineering Associate occupation.

Appendix 2 Contrasting Associate Degrees offered by the University of South Australia

Provided by Associate Professor Brenton Dansie, UniSA, to the ALTC project

AN ASSOCIATE DEGREE PATHWAY TO THE BACHELOR OF ENGINEERING

Since 2008 the University of South Australia has offered an Associate Degree in Engineering as a pathway for students into its four year professional engineering degrees. The program was introduced in response to a perceived need to expand the pool of potential four year degree applicants. One group which had expressed interest in further engineering studies were people who were currently working, and often had a trade background. Whilst the University had previously run bridging/enabling programs and offers a foundation studies program, it was thought to be useful to develop a pathway in which students could be introduced to some elements of Engineering practice whilst they were developing the Mathematics and Science knowledge and skills they required for the more technical aspects of Engineering.

Entry into the program was available through the standard entry mechanisms including Year 12 studies for students who did not meet either the cut-off or the pre-requisites of entry into the four-year degree. In addition, the ATN Engineering Selection test (ATN, 2007) was used to measure students' general aptitude on three scales: quantitative reasoning and problem solving, scientific and critical reasoning, and interpersonal reasoning.

The Associate Degree was developed as a sequence of 4 bridging courses, the eight common first-year courses from the BEng degree and four courses taken from the second year of the mechanical, electrical and civil engineering programs. Students can transfer into a four-year engineering degree when they have successfully completed all 16 courses or after completing at least 8 courses. Students receive a direct credit for all of the courses they have done in the Associate Degree except for any of the four bridging courses which are not credited into the BEng degree.

Of the 66 students who enrolled in the first intake of 2008, over half qualified for admission via the ATN test, with the other entrants being school leavers, or having previously studied at a TAFE. After two years, 17 per cent of this first entry cohort have transferred to the BEng program and a further 4 per cent have transferred to a program other than engineering. A further 39 per cent were still actively studying in the program. A large proportion of the students study part-time and therefore could not complete the program in two years. In total then, 60 per cent of the students are making reasonable progress in their studies.

The success of integrating students from this pathway into the degree is demonstrated by their comparable level of success in common first year degree subjects with the overall student cohort.

THE ASSOCIATE DEGREE (DEFENCE SYSTEMS): A ROUTE TO EMPLOYMENT

This Associate Degree is aimed to provide a qualification for the Engineering Associate occupation. The program design has moved away from that adopted in advanced diplomas because its aim is to cater for the educational needs of experienced tradespeople seeking to move into engineering management at the implementation or practical level. The associate degree graduates will require a higher level of cognitive skills than is apparent in current training package based VET diploma and advanced diploma qualifications. The students' trade and work skills need to be supplemented with knowledge of practical engineering mathematics, higher level engineering management practices and exposure to other disciplines. There is therefore a need to shift the students' ways of thinking and attitudes towards management and problem solving that are commensurate with those of higher education and the role of the engineer.

The program is a response to the results of a 2006/7 survey of the skills needs of the South Australian defence industry which identified the need for 'para professionals' in the industry. Further work articulated the need, the history behind the skills shortage and fleshed out a suitable curriculum in association with the defence industry. As a consequence, the language, processes and culture of the defence industry are specifically addressed in the curriculum.

A concern has arisen that HR and IR structures within companies are having difficulty with the wage, salary and career issues surrounding graduates of the program. The employment and career conditions of tradespeople are clearly defined by AQF VET qualifications linked to the IR awards. Engineers are similarly bounded by APESMA salary classifications and Engineers Australia's professional standing classifications, particularly at the CPEng level. This does not appear to be the case with Associate Degree graduates who, to the HR/IR community appear to be neither fish nor fowl. This is an issue which requires further study.

Appendix 3 Australian Engineering Schools and areas of their accredited programs, 2011

							B.Eng programs fully or provisionally accredited by Engineers Accreditation in identified discipline areas. (M denotes the accredited award is a Masters degree: P denotes a 2-year pathway to an accredited program delivered elsewhere)												
university	Group	location of engineering in academic structure	senior executive resp. for engin'g	academic sub-structure for engineer'g	size	% int'l	Civil	Mech, Manuf, Industrial	Elec, Electron, Tele. Comp	Chemical	Mining	Software	Aerospace	Naval Arch.	Biomedical	Environmental	Mechtronics & Robotics	other	acccredited B.Tech Associate Degree	off-shore accredited engineering programs
UNSW@ADFA	Go8	School of Engineering &	HoS	none	S	S	x	x	x				x						x	
University of Canberra	metro	Faculty of Information Sciences & Engineering	Dean	1 eng. discipline	S	S			x			x								
The Australian National University	Go8	College of Engineering & Computer Science	Dean & Director	2 depts	S	H		x	x			x				x	x		AD	
Macquarie University	metro	Faculty of Science	Dean	1 eng dept	S	S			x								x			
The University of New South Wales	Go8	Faculty of Engineering	Dean	9 eng schools	L	H	x	x	x	x	x	x	x	x	M	x	x	Petrolm Photo & Renew Energy		
The University of Newcastle	IRU*	Faculty of Engineering and Built Environment	Pro Vice Chancellor	2 eng schools	M	H	x	x	x	x	P	x				x	x			x
The University of New England	regional	School of Environmental & Rural Science (Faculty of Arts and Science)	Head of School	none	S	S													BT	
The University of Sydney	Go8	Faculty of Engineering & Information Technologies	Dean	4 eng schools	L	M	x	x	x	x		x	x		x		x			
University of Technology, Sydney	ATN (Tech)	Faculty of Engineering & Information Technology	Dean	4 eng schools	L	M	x	x	x			x				x	x	also Dipl Eng. Prac		x
University of Western Sydney	metro	College of Health & Science (School of Engineering)	Executive Dean	1 eng school	M	S	x	x	x							x	x			
University of Wollongong	metro*	Faculty of Engineering (FoE) Faculty of Informatics (Info)	Deans (2)	eng in 3 schools	M	M	x	x	x		x					x	x	materials	x	

							B.Eng programs fully or provisionally accredited by Engineers Accreditation in identified discipline areas. (M denotes the accredited award is a Masters degree: P denotes a 2-year pathway to an accredited program delivered elsewhere)													
university	Group	location of engineering in academic structure	executive position resp. for engin'g	academic sub-structure for engineer'g	size	% int'l	Civil	Mech, Manuf, Industrial	Elec, Electron, Tele. Comp	Chemical	Mining	Software	Aerospace	Naval Arch.	Biomedical	Environmental	Mechtronics & Robotics	other	acccredited B.Tech Associate Degree	off-shore accredited engineering programs
Charles Darwin University	regional	Faculty of Education, Health & Science	Dean	1 eng school	S	M	x	x	x											
Central Queensland University	regional	Faculty of Science, Engineering & Health	Pro Vice Chancellor	1 eng school	S	S	x	x	x										AD BT	
Griffith University	IRU	Fac of Science, Environment , Eng. and Technology	Pro Vice Chancellor	3 schools with eng	M	M	x		x			x				x	x	sust. energy		
James Cook University	IRU	Fac. of Science, Engineering & Information Technology	Pro Vice Chancellor	1 eng school	M	S	x	x	x	x						x				
Queensland University of Technology	ATN (Tech)	Faculty of Built Environment & Engineering	Executive Dean	2 schools with eng.	L	M	x	x	x			x	x		x	x	x		x	
The University of Queensland	Go8	Faculty of Engineering, Architecture & Infrmation Technology	Executive Dean	4 eng schools	L	M	x	x	x	x	x	x	x		x	x	x	metallurg, materials		
University of Southern Queensland	regional	Faculty of Engineering & Surveying	Dean	3 eng disciplines	M	S	x	x	x			x				x	x	agric eng. M.Eng. Practice	AD BT	
University of the Sunshine Coast	metro	Faculty of Science, Health & Education	Dean	eng in sch of science & education	S	S	x													
University of Tasmania	metro	Faculty of Science, Engineering & Technology	Dean	1 eng school	S	H	x	x	x										x	x
Aust. Maritime Coll. (part of UTas)		Department of Maritime Engineering	Head	none	S	S								x				several		

							B.Eng programs fully or provisionally accredited by Engineers Accreditation in identified discipline areas. (M denotes the accredited award is a Masters degree: P denotes a 2-year pathway to an accredited program delivered elsewhere)													
university	group	location of engineering in academic structure	executive position resp. for engin'g	academic sub-structure for engineer'g	size	% int'l	Civil	Mech, Manuf, Industrial	Elec, Electron, Tele. Comp	Chemical	Mining	Software	Aerospace	Naval Arch.	Biomedical	Environmental	Mechtronics & Robotics	other	acccredited B.Tech Associate Degree	off-shore accredited engineering programs
The Flinders University of South Australia	IRU	Faculty of Science & Engineering	Executive Dean	1 school with eng	S	S	x	x	x			x		x	x	x	x		BT*	
The University of Adelaide	Go8	Faculty of Engineering, Computer & Mathematical Sciences	Executive Dean	5 schools with eng	L	M	x	x	x	x	x	x	x		x	x	x	pharma, sports		
University of South Australia	ATN (Tech)	Division of Information Technology, Engineering & the Environment	Pro Vice Chancellor	3 schools with eng	M	H	x	x	x							x	x		AD* BT	x
Deakin University	metror	Faculty of Science & Technology	Dean	1 eng school	S	M	x	x	x								x			
La Trobe University	IRU	Faculty of Science, Technology & Engineering	Dean	2 eng schools	S	M	x		x										BT	
Monash University	Go8	Faculty of Engineering	Dean	8 eng schools	L	H	x	x	x	x		x	x			x	x	pharma.	BT	x
RMIT University	ATN (Tech)	College of Science, Engineering & Technology	Pro Vice Chancellor	3 eng schools	L	H	x	x	x	x		x	x			x	x		AD	x
Swinburne Uni. of Technology	Tech	Faculty of Engineering and Industrial Sciences	Dean	none	L	H	x	x	x			x			x		x	product design	AD	x
The University of Melbourne	Go8	Melbourne School of Engineering	Dean	5 eng departments	L	H	x M	x M	x M	x M		x M			x M	x M	x M			
University of Ballarat	regional	School of Science & Engineering	Head	1 eng area	S	S	M	M			M						x		BT	

university	group	location of engineering in academic structure	executive position resp. for engin'g	academic sub-structure for engineer'g	size	% int'l	Civil	Mech, Manuf, Industrial	Elec, Electron, Tele. Comp	Chemical	Mining	Software	Aerospace	Naval Arch.	Biomedical	Environmental	Mechtronics & Robotics	other	accredited B.Tech Associate Degree	off-shore accredited engineering programs
Victoria University	metro	Faculty of Heath, Engineering & Science	Executive Dean	2 eng schools	M	S	x	x	x									arch. sportsl	AD	
Curtin University of Technology	ATN (Tech)	Faculty of Science & Engineering (also Dean of Eng)	Pro Vice Chancellor	6 eng, schools	L	H	x	x	x	x	x	x					x	met petro		x
Edith Cowan University	metro	Faculty of Computing, Health & Science	Executive Dean	1 eng school	M	S	x	x	x								x		BT	x
Murdoch University	IRU	Faculty of Science & Engineering	Faculty Dean	1 eng school (School Dean)	S	S		x	x	x		x				x	x	bioproc., renew energy	BT	
The University of Western Australia	Go8	Faculty of Engineering, Computing & Mathematics	Dean	5 eng schools	L	M	x	x	x	x	x					x	x	oil & gas		

B.Eng programs fully or provisionally accredited by Engineers Accreditation in identified discipline areas. (M denotes the accredited award is a Masters degree: P denotes a 2-year pathway to an accredited program delivered elsewhere)

key to groups: See Table 2 in text
ATN: Australian Technology Network (also 'Tech' see Text)
Go8: Group of 8 universities
IRU: Innovative Research Universities
Metro and Regional, as in Table 2.

note s

UoW and UoNewcastle are associate members of the Go8 Engineering Deans group
"BTech and Assoc Degree programs likely to seek accreditation

key to size bands:
based on commencing BEng
L > 700 (max ~ 1850)
M 200 to700
S < 200 (min ~ 30)

key to international % bands
(includes offshore):
H > 30% (max ~ 65.4%)
M 20% to 30%
S < 20% (min ~ 1%)

data sources:
student numbers: DEEWR
engineering academic structures: university websites
accredited program areas: Engineers Australia website (March 2011) and university website course information for prospective students

Appendix 4 Higher Education Completions in Engineering & Related Technologies DEEWR data 1996 – 2009

	1996	1998	2000	2002	2004	2005	2006	2007	2008	2009
DOCTORATES	**413**	**438**	**474**	**480**	**570**	**637**	**695**	**772**	**697**	**705**
domestic total	291	325	355	381	421	452	487	519	513	479
% domestic female	14.8%	19.1%	18.9%	17.1%	20.9%	21.2%	20.1%	21.4%	24.2%	21.1%
international total	122	113	119	99	149	185	208	253	184	226
% international female	7.4%	9.7%	8.4%	15.2%	14.8%	16.8%	16.8%	18.2%	17.4%	19.9%
% international	29.5%	25.8%	25.1%	20.6%	26.1%	29.0%	29.9%	32.8%	26.4%	32.1%
RESEARCH MASTER'S	**237**	**230**	**189**	**185**	**220**	**208**	**264**	**230**	**228**	**185**
domestic total	178	164	143	144	147	133	139	135	127	99
% domestic female	23.6%	15.2%	27.3%	22.9%	17.0%	23.3%	24.5%	25.9%	19.7%	18.2%
international total	59	66	46	41	73	75	125	95	101	86
% international female	10.2%	19.7%	23.9%	12.2%	19.2%	21.3%	17.6%	21.1%	24.8%	25.6%
% international	24.9%	28.7%	24.3%	22.2%	33.2%	36.1%	47.3%	41.3%	44.3%	46.5%
COURSEWORK MASTER'S	**831**	**972**	**1,052**	**1,695**	**2,587**	**2,934**	**2,406**	**2,586**	**2,878**	**3,134**
domestic total	508	567	458	624	645	635	576	686	690	788
% domestic female	11.0%	12.9%	18.1%	18.1%	16.6%	18.0%	15.5%	20.1%	18.3%	17.6%
international total	323	405	594	1,071	1,942	2,299	1,830	1,900	2,188	2,346
% international female	9.9%	13.3%	17.3%	18.8%	17.1%	17.0%	15.9%	15.4%	18.4%	18.8%
% international	38.9%	41.7%	56.5%	63.2%	75.1%	78.4%	76.1%	73.5%	76.0%	74.9%
OTHER POSTGRADUATE	**630**	**651**	**513**	**484**	**528**	**558**	**655**	**659**	**763**	829
domestic total	545	523	424	334	409	363	417	447	522	588
% domestic female	13.8%	12.6%	12.7%	16.5%	20.0%	17.9%	16.1%	22.4%	20.9%	19.0%
international total	85	128	89	150	119	195	238	212	241	241
% international female	11.8%	7.8%	14.6%	14.7%	13.4%	19.0%	13.0%	14.6%	19.5%	17.0%
% international	13.5%	19.7%	17.3%	31.0%	22.5%	34.9%	36.3%	32.2%	31.6%	29.1%
BACHELOR'S	**6,008**	**6,559**	**6,613**	**7,469**	**8,200**	**8,076**	**8,369**	**8,076**	**8,661**	**8,652**
domestic total	5,289	5,550	5,190	5,721	5,980	5,680	6,026	5,786	6,077	6,063
% domestic female	14.3%	15.0%	14.9%	16.9%	16.3%	16.7%	16.0%	14.8%	14.7%	14.9%
international total	719	1,009	1,423	1,748	2,220	2,396	2,343	2,290	2,584	2,589
% international female	13.9%	14.2%	16.1%	18.5%	19.2%	18.3%	18.7%	19.8%	21.2%	18.3%
% international	12.0%	15.4%	21.5%	23.4%	27.1%	29.7%	28.0%	28.4%	29.8%	29.9%
ASSOC DEG & AQF ADV DIPLOMA	**206**	**74**	**120**	**222**	**182**	**190**	**97**	**159**	**564**	**369**
domestic total	194	66	112	186	124	141	87	133	175	278
% domestic female	4.1%	6.1%	5.4%	5.4%	7.3%	5.0%	4.6%	9.0%	11.4%	8.6%
international total	12	8	8	36	58	49	10	26	389	91
% international female	0.0%	0.0%	0.0%	0.0%	43.1%	14.3%	0.0%	7.7%	20.8%	4.4%
% international	5.8%	10.8%	6.7%	16.2%	31.9%	25.8%	10.3%	16.4%	69.0%	24.7%
OTHER UNDERGRADUATE	**11**	**76**	**9**	**297**	**456**	**191**	**376**	**510**	**76**	**314**
domestic total	11	75	9	292	444	173	258	233	60	60
% domestic female	0.0%	1.3%	0.0%	4.5%	0.2%	2.9%	1.9%	6.4%	15.0%	8.3%
international total		1	-	5	12	18	118	277	16	254
% international female		0.0%		20.0%	16.7%	27.8%	40.7%	29.2%	31.3%	13.8%
% international	0.0%	1.3%	0.0%	1.7%	2.6%	9.4%	31.4%	54.3%	21.1%	80.9%
ALL GRADUATES	**8,336**	**9,000**	**8,970**	**10,832**	**12,743**	**12,794**	**12,862**	**12,992**	**13,867**	**14,188**
domestic total	7,016	7,270	6,691	7,682	8,170	7,577	7,990	7,939	8,164	8,355
% domestic female	14.0%	14.6%	15.3%	16.4%	15.8%	16.7%	15.8%	15.9%	16.0%	15.6%
international total	1,320	1,730	2,279	3,150	4,573	5,217	4,872	5,053	5,703	5,833
% international female	11.9%	13.4%	16.1%	18.0%	18.3%	17.7%	17.8%	18.3%	20.0%	18.2%
% international	15.8%	19.2%	25.4%	29.1%	35.9%	40.8%	37.9%	38.9%	41.1%	41.1%

Appendix 5 Admission requirements for the Associate Degree of Engineering at the University of Southern Queensland

Applicants shall normally:

have studied four semester units and achieved an exit assessment of 'Sound Achievement' or better in the Queensland Senior Secondary School subject: English. It is recommended that applicants should also have satisfactorily completed the subject: Mathematics B (Mathematics A is assumed)

or

be able to demonstrate that they have achieved an equivalent standard in these subjects at another institution,

and

Australian applicants: have achieved a Queensland Overall Position (OP) band, or an equivalent Rank based on qualifications and previous work experience, at or above the specified cut-off level*

International applicants: must have met the University's English language requirements or have completed the University's ELICOS/EAP program.

**Note:* The Queensland Tertiary Admission Centre (QTAC) allocates a Rank after assessing the qualifications and work experience of mature-age applicants who do not have an OP band from their secondary school studies and apply for Alternative Entry. Many applicants with Certificate III qualifications in relevant engineering trades receive a Rank at or above the specified cut-off, and are admitted to the Associate Degree of Engineering.*

Source: University of Southern Queensland

Appendix 6 Current offers of VET Diploma and Advanced Diploma Programs

The data in the following three tables was extracted from government and institution websites in 2010 and updated in early 2011. It should be noted that although an institutions may be registered to offer a program it may, for a variety of reasons, not offer that program. While every effort has been made to identify and list all Diploma and Advanced Diploma engineering programs, readers should check with individual institutions and RTOs about the programs they offer.

Electrical and Electronic Engineering programs - UEE Training Package qualifications

			Diploma					Advanced Diploma								
	City	Institution	UEE50107	UEE50407	UEE50507	UEE50707	UEE50907	UEE60107	UEE60207	UEE60407	UEE60607	UEE60707	UEE60907	UEE61207	UEE60307	UEE61307
VIC	Melbourne	Chisholm Institute of TAFE	**						**	**						
	Melbourne	Northern Melbourne Institute of TAFE			**					**						
	Melbourne	Swinburne University of Technology							**	**						**
	Melbourne	RMIT Institute of Technology		**					**	**						**
	Melbourne	AOI Institute			**											
	Melbourne	Menzies Institute of Technology			**											
	Melbourne	Victoria University						**		**						**
	Melbourne	Box Hill Institute of TAFE								**						
	Melbourne	Kangan Batman Institute of TAFE								**						
	Bendigo	Bendigo Regional Institute of TAFE			**											
	Geelong	Gordon Institute of TAFE								**						
	Warrnambool	South West Institute of TAFE								**						
NSW	Sydney	TAFE NSW - Sydney Institute		**				**							**	**
	Sydney	TAFE NSW - South Western Sydney Institute		**	**			**	**		**					
	Sydney	TAFE NSW – Western Institute		**	**											
	Sydney	TAFE NSW - Western Sydney Institute		**	**			**	**		**		**		**	**
	Sydney	TAFE NSW – OTEN – Distance Education		**				**								
	Newcastle	TAFE NSW - Hunter Institue		**			**	**								
	Port Macquarie	TAFE NSW - North Coast Institute		**												
	Tamworth	TAFE NSW - New England Institute		**				**								
	Wagga Wagga	TAFE NSW - Riverina Institute		**	**			**								
	Wollongong	TAFE NSW - Illawarra Institute		**				**								
QLD	Brisbane	SkillsTech Australia			**			**	**	**					**	**
	Brisbane	Careers Australia Institute of Training				**										
	Toowoomba	SvB ExTech												**		
SA	Adelaide	TAFE SA Regency Campus	**		**				**	**						**
WA	Perth	Central Institute of Technology	**		**				**	**						
ACT	Canberra	Canberra Institute of Technology		**											**	
TAS	Hobart	Tasmanian Polytechnic			**											
Multi	Qld WA	Project management Vision		**												

Civil Engineering (RII) and Mechanical Engineering (MEM) Training Package Qualifications						
			MEM			RII
			Diploma		AD	Dip
State	City	Institution	MEM50105	MEM50205	MEM60105	RII5059
VIC	Melbourne	RMIT Institute of Technology	**			
	Melbourne	Swinburne University of Technology	**	**	**	
	Melbourne	Kangan Batman Institute of TAFE	**	**	**	
	Melbourne	Chisholm Institute of TAFE	**			
	Melbourne	Holmesglen Institute of TAFE	**			
	Melbourne	Northern Melbourne Institute of TAFE	**			
	Melbourne	Victoria University	**			
	Ballarat	University of Ballarat	**	**	**	
	Bendigo	Bendigo Regional Institute of TAFE		**		
	Geelong	Gordon Institute of TAFE	**			
	Mildura	Sunraysia Institute of TAFE	**			
	Morwell	Central Gippsland Institute of TAFE	**			
	Shepparton	Goulburn Ovens Institute	**			
	Wodonga	Wodonga Institute of TAFE	**			
NSW	Sydney	TAFE NSW - Sydney Institute		**	**	**
	Sydney	TAFE NSW - South Western Sydney Institute	**	**	**	
	Sydney	TAFE NSW - Western Sydney Institute		**	**	**
	Newcastle	TAFE NSW - Hunter Institute		**	**	
	Port Macquarie	TAFE NSW - North Coast Institute	**			
	Wagga Wagga	TAFE NSW –Riverina Institute				**
	Wollongong	TAFE NSW - Illawarra Institute		**	**	**
QLD	Brisbane	SkillsTech Australia	**	**	**	
	Cairns	Tropical North Institute	**			
	Toowoomba	Southern Queensland Institute	**	**		
	Townsville	Barrier Reef Institute		**		
SA	Adelaide	TAFE SA Regency Campus	**			
	Adelaide	TAFE SA Panorama Campus		**	**	
	Whyalla	TAFE SA Regional	**			
WA	Perth	Central Institute of Technology		**	**	
	Fremantle	Challenger Institute of Technology		**	**	
	Perth	Polytechnic West		**		
	Bunbury	South West Institute of Technology		**		
Multi	Qld, NSW	Careers Australia Institute of Training	**			

State Accredited Courses – Civil, Electrical and Mechanical Engineering

			Civil						Mechanical				Electrical			
			Diploma			Advanced Diploma			Diploma	Advanced Diploma			Dip	Advanced Diploma		
State	City	Institution	40603SA	52012	39141QLD	40604SA	52011	91155NSW	21621VIC.	21622VIC	15696VIC	14309VIC	51700	51974	91035NSW	91037NSW
VIC	Melbourne	Northern Melbourne Institute of TAFE	**			**			**	**		**				
	Melbourne	RMIT Institute of Technology	**			**			**	**	**	**				
	Melbourne	Kangan Batman Institute of TAFE							**	**	**					
	Melbourne	Box Hill Institute of TAFE							**	**						
	Melbourne	Holmesglen Institute of TAFE							**	**						
	Melbourne	Swinburne University							**			**				
	Melbourne	Chisholm Institute of TAFE							**	**						
	Melbourne	Victoria University							**	**		**				
	Ballarat	University of Ballarat							**	**						
	Bendigo	Bendigo Regional Institute of TAFE							**							
	Morwell	Central Gippsland Institute of TAFE							**	**						
	Geelong	Gordon Institute of TAFE								**		**				
	Shepparton	Goulburn Ovens Institute of TAFE	**							**						
	Wodonga	Wodonga Institute of TAFE							**	**						
NSW	Sydney	TAFE NSW - Sydney Institute						**								
	Sydney	TAFE NSW - Western Sydney Institute						**								
	Sydney	TAFE NSW – Institute													**	**
QLD	Gold Coast	Gold Coast Institute of TAFE	**			**										
SA	Adelaide	TAFE SA Panorama Campus	**			**										
WA	Perth	Central Institute of Technology		**			**									
	Fremantle	Challenger Institute of Technology		**			**						**	**		
	Bunbury	South West Institute of Technology		**												
ACT	Canberra	Canberra Institute of Technology	**			**										
TAS	Burnie	Tasmanian Polytechnic	**			**										

Appendix 7 Guidelines on Entry Requirements and Recognition of Prior Learning for TAFE WA DIPLOMATES at Curtin University of Technology

Source: Curtin University of Technology, information valid for November 2010

TAFE WA (see note 1 below) qualified applicants shall be granted entry to a Bachelor of Engineering Degree Course and receive credit (typically 150 Credit Points) for part of the first year [Engineering Foundation Year, EFY] of the Degree Course as recognised prior learning (RPL) subject to:

- holding the TAFE Award (or replaced award) in the appropriate (aligned) discipline as shown below [See note 2 below]
- quota places being available.

Successful completion, within the award, of mathematics unit combinations equivalent to the following will also give eligibility for a further 50 Credit Point RPL in lieu of the EFY units; Engineering Mathematics 120 and Engineering Mathematics 140:

MEM 23001 Apply advanced mathematical techniques in a manufacturing engineering or related environment AND MEM23002A Apply calculus in engineering situations

or

43746 EB004 University Bridging Mathematics 1" AND 43302 EA001 Calculus

or

41964 Use Advanced Mathematics in Engineering AND 41966 Use Calculus in Engineering

CURTIN DEGREE PROGRAM	QUALIFYING TAFE AWARD
Bachelor of Engineering (Civil and Construction Engineering)	52011/ 3356 Advanced Diploma of Civil and Structural Engineering *Replacing* *51519/ 3333 Advanced Diploma of Drafting and Design (Civil Engineering)* *51520/ 3334 Advanced Diploma of Drafting and Design (Structural Engineering)*
Bachelor of Engineering (Mechanical Engineering)	MEM60105/ WT53 Advanced Diploma of Engineering (Mechanical) *Replacing* *50944/ MS60 Advanced Diploma of Engineering (Mechanical)*
Bachelor of Engineering (Mechatronic Engineering)	MEM60105/ WT53 Advanced Diploma of Engineering (Mechanical) *Replacing* *50944/ MS60 Advanced Diploma of Engineering (Mechanical)*
Bachelor of Engineering (Computer Systems Engineering)	UEE 50107/ W462 Diploma of Computer Systems Engineering (2 year) UEE60407 Advanced Diploma of Computer Systems Engineering (2.5 year) *Replacing* *51540 Advanced Diploma of Electrotechnology (Computer Systems)* *UEE60407 Advanced Diploma of Computer Systems Engineering*
Bachelor of Engineering (Electrical Power Engineering)	5440 Diploma of Electrotechnology (Electrical Systems) (2 year) *Replacing* *Advanced Diploma of Electrotechnology (Electrical systems)*
Bachelor of Engineering (Electronic & Communications Engineering)	UEE50507/ W466 Diploma of Electronics and Communications (2 year) UEE50207/ W472 Advanced Diploma of Electronics and Communications Engineering (2.5 years) *Replacing*

	UEE60207 Advanced Diploma of Electronics and Communications Engineering *Advanced Diploma of Electrotechnology (Industrial electronics and Instrumentation)*
Bachelor of Engineering (Chemical Engineering) Bachelor of Engineering (Petroleum Engineering)	52170/8989 Advanced Diploma of Engineering (Oil and Gas) (2 Year) [Note 3]

Notes:

1. The West Australian TAFE institutions recognised are;

   Central Institute of Technology
   Challenger Institute of Technology
   *Polytechnic West**

   **NB. At this stage the Advanced Diploma from Polytechnic West attracts a maximum of 175 CP of RPL. Enrolment in Engineering Maths 140 is required in the first semester.*

2. Holders of Advanced Diplomas have in previous years been essentially restricted to places in BEng courses (majors) specific to the discipline studied in the Advanced Diploma. Whilst this remains the recommendation, applicants may be considered for alternative BEng majors, at the discretion of the pursuant Department. Therefore the letter of offer should stipulate words to the following effect:
   "….offered a place in BEng (specified course major). Any variation to the course major stated above is subject to review by the pursuant engineering Department at the time of enrolment…."

3. The mapping of this program revealed a deficiency in mathematics treatment; therefore holders still need to complete Engineering Mathematics 140. To enable 200 Credit Points RPL to be awarded for this qualification a second year unit in the BEng program(s) needs to be designated for RPL. For Chemical Engineering this 'exempt' second year unit will be Chemistry 101; for Petroleum Engineering - TBA.

General Note:
Applicants possessing TAFE Diplomas of one year duration are not eligible for entry into Engineering. However, they may be eligible for entry into BSc (Multi Science).

Appendix 8 Basis of Admission: domestic bachelor degree commencements In Engineering and Related Technologies for selected universities, 2001 – 8. (Godfrey, E & King, R, 2011)

		total number	higher Ed complete/ incomp (Aus or O/S)	TAFE/VET award complete/ incomp .	mature, special, profess-ional, or employ-ment	completed final year of secondary at school or TAFE (Aus or O/S)	exam or assessed by institution	other, inc. Open Learning & special entry	not stated
AUSTRALIAN TOTAL	2001	10,786	12.6%	4.1%	2.8%	70.5%	3.9%	5.7%	0.3%
	2002	10,278	12.0%	5.1%	3.3%	71.8%	2.5%	5.3%	0.0%
	2003	10,089	13.4%	7.4%	3.4%	70.3%	2.8%	2.7%	0.0%
	2004	9,910	14.4%	6.8%	3.1%	71.1%	2.6%	2.0%	0.0%
	2005	9,920	16.2%	7.1%	2.7%	65.7%	0.0%	8.4%	0.0%
	2006	10,288	13.4%	6.2%	2.2%	64.2%	0.0%	12.3%	1.7%
	2007	11,051	14.4%	6.4%	2.2%	67.1%	0.0%	7.3%	2.6%
	2008	11,295	15.3%	6.1%	2.3%	64.7%	0.0%	8.7%	2.9%
University of Technology, Sydney	2001	517	5.2%	9.9%	1.0%	80.7%	1.0%	2.1%	0.2%
	2002	430	8.1%	8.8%	1.6%	73.5%	0.0%	7.9%	0.0%
	2003	476	8.8%	13.4%	1.5%	68.9%	4.4%	2.9%	0.0%
	2004	518	14.5%	13.5%	0.4%	68.5%	2.1%	1.0%	0.0%
	2005	556	15.6%	14.4%	1.6%	68.2%	0.0%	0.2%	0.0%
	2006	533	11.8%	13.7%	2.6%	37.5%	0.0%	32.8%	1.5%
	2007	480	17.1%	12.5%	2.5%	39.2%	0.0%	27.9%	0.8%
	2008	569	13.5%	13.5%	1.1%	25.0%	0.0%	45.5%	1.4%
CQ University	2001	194	37.1%	1.0%	12.4%	38.7%	2.1%	8.8%	0.0%
	2002	203	16.3%	8.9%	16.3%	53.2%	5.4%	0.0%	0.0%
	2003	163	15.3%	11.0%	15.3%	55.8%	1.8%	0.6%	0.0%
	2004	196	41.3%	5.6%	9.7%	36.2%	6.6%	0.5%	0.0%
	2005	201	24.9%	7.0%	9.0%	50.7%	0.0%	8.5%	0.0%
	2006	206	18.4%	6.3%	6.3%	57.8%	0.0%	11.2%	0.0%
	2007	202	34.2%	4.5%	3.0%	50.0%	0.0%	8.4%	0.0%
	2008	164	34.1%	0.6%	1.2%	61.6%	0.0%	1.8%	0.6%
Charles Darwin University	2001	20	0.0%	20.0%	5.0%	65.0%	0.0%	10.0%	0.0%
	2002	20	5.0%	5.0%	10.0%	70.0%	0.0%	10.0%	0.0%
	2003	15	33.3%	0.0%	33.3%	33.3%	0.0%	0.0%	0.0%
	2004	50	30.0%	6.0%	10.0%	38.0%	0.0%	16.0%	0.0%
	2005	53	45.3%	7.5%	0.0%	41.5%	0.0%	5.7%	0.0%
	2006	21	19.0%	0.0%	0.0%	76.2%	0.0%	0.0%	4.8%
	2007	46	6.5%	0.0%	4.3%	82.6%	0.0%	6.5%	0.0%
	2008	27	33.3%	0.0%	3.7%	55.6%	0.0%	7.4%	0.0%

		total number	higher Ed complete/ incomp (Aus or O/S)	TAFE/VET award complete/ incomp.	mature, special, profess-ional, or employ-ment	completed final year of secondary at school or TAFE (Aus or O/S)	exam or assessed by institution	other, inc. Open Learning & special entry	not stated
University of Southern Queensland	2001	446	35.4%	6.5%	12.3%	36.1%	5.6%	4.0%	0.0%
	2002	453	19.4%	5.3%	8.4%	32.2%	5.5%	29.1%	0.0%
	2003	458	33.8%	12.2%	14.2%	27.3%	9.8%	2.6%	0.0%
	2004	409	36.7%	10.8%	10.5%	33.3%	2.9%	5.9%	0.0%
	2005	484	53.1%	10.1%	6.0%	24.8%	0.0%	6.0%	0.0%
	2006	394	41.6%	11.7%	7.6%	30.5%	0.0%	7.4%	1.3%
	2007	403	33.3%	15.6%	8.4%	29.3%	0.0%	12.7%	0.7%
	2008	477	37.5%	11.9%	6.5%	27.3%	0.0%	16.4%	0.4%
RMIT University	2001	771	10.0%	5.2%	0.3%	69.6%	14.9%	0.0%	0.0%
	2002	823	7.7%	8.7%	0.0%	72.7%	10.9%	0.0%	0.0%
	2003	667	16.5%	9.9%	0.0%	63.9%	9.7%	0.0%	0.0%
	2004	501	20.6%	15.2%	0.0%	61.7%	2.6%	0.0%	0.0%
	2005	676	21.3%	19.4%	0.4%	58.9%	0.0%	0.0%	0.0%
	2006	776	16.4%	16.0%	0.4%	66.8%	0.0%	0.0%	0.5%
	2007	791	18.3%	15.2%	1.0%	65.0%	0.0%	0.0%	0.5%
	2008	838	17.1%	17.9%	1.9%	62.5%	0.0%	0.0%	0.6%
Swinburne University of Technology	2001	477	22.4%	6.1%	0.0%	68.1%	3.4%	0.0%	0.0%
	2002	512	16.8%	6.1%	0.8%	68.2%	8.2%	0.0%	0.0%
	2003	532	22.7%	14.8%	0.0%	61.5%	0.9%	0.0%	0.0%
	2004	523	16.4%	18.5%	0.0%	63.1%	1.9%	0.0%	0.0%
	2005	586	17.9%	14.5%	0.0%	63.7%	3.9%	0.0%	0.0%
	2006	558	14.0%	17.2%	0.0%	65.6%	2.9%	0.0%	0.4%
	2007	587	19.6%	12.6%	0.0%	63.0%	3.6%	0.0%	1.2%
	2008	581	28.7%	13.1%	0.0%	53.5%	4.6%	0.0%	0.0%
University of Ballarat	2001	35	22.9%	8.6%	14.3%	54.3%	0.0%	0.0%	0.0%
	2002	51	7.8%	7.8%	5.9%	74.5%	3.9%	0.0%	0.0%
	2003	41	9.8%	12.2%	4.9%	61.0%	12.2%	0.0%	0.0%
	2004	62	8.1%	3.2%	16.1%	69.4%	3.2%	0.0%	0.0%
	2005	60	11.7%	3.3%	11.7%	66.7%	6.7%	0.0%	0.0%
	2006	63	14.3%	0.0%	1.6%	68.3%	15.9%	0.0%	0.0%
	2007	76	21.1%	3.9%	0.0%	53.9%	21.1%	0.0%	0.0%
	2008	69	42.0%	2.9%	4.3%	43.5%	7.2%	0.0%	0.0%
University of South Australia	2001	377	7.2%	3.7%	8.0%	78.0%	0.0%	3.2%	0.0%
	2002	290	11.4%	6.2%	4.5%	72.1%	0.0%	5.9%	0.0%
	2003	287	12.5%	8.4%	12.9%	63.8%	0.3%	2.1%	0.0%
	2004	213	14.1%	6.6%	6.6%	71.4%	0.0%	1.4%	0.0%
	2005	219	16.9%	11.9%	3.7%	63.0%	0.0%	4.6%	0.0%
	2006	231	10.4%	6.1%	4.8%	74.0%	0.0%	4.3%	0.4%
	2007	182	3.8%	14.8%	6.6%	67.0%	0.0%	3.3%	4.4%
	2008	181	6.1%	9.9%	4.4%	75.7%	0.0%	1.7%	2.2%