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Submission

The shortage of engineering and related employment skills

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Introduction

Chisholm Institute, the largest of Victoria's TAFE Institutes, was registered by the Victorian Registration and Qualifications Authority in 2010 as a higher education provider. Thus, with the formation of the new national regulatory body, it is registered as a higher education provider with the Tertiary Education Quality and Standards Agency.

Based in the south-eastern suburbs of Melbourne; a region responsible for 44% of Victoria's total manufactured product, Chisholm is a founder member of the rapidly growing South East Melbourne Manufacturers Alliance Inc. (SEMMA). SEMMA currently has a membership of approximately 180 companies.

Chisholm students range from those still attending high school, through apprentices and trainees and those gaining certification in particular skills for their jobs, to those earning industry ready specialist degrees. An outstanding provider of quality further and higher education in Victoria, Chisholm Institute has earned a strong reputation for combining academic achievement with close and ongoing partnerships with industry.

Chisholm currently has the only Engineers Australia [1] accredited engineering technologist program outside of the Australian university sector. This unique three year Bachelor of Engineering Technology program was developed in close consultation with local industry and membership organisations including Engineers Australia (Victoria); SEMMA and the South East Business Network (SEBN) to ensure the program is relevant now and well into the future. The program is located in the new well equipped $14million Centre for Integrated Engineering and Science ensuring students have high level access to the latest industry standard technology.

The unique features of the Chisholm Bachelor of Engineering Technology program are centred on industry project based learning aligned with the teaching strategies of the CDIO Initiative. The CDIO Initiative is a Massachusetts Institute of Technology led worldwide engineering education alliance 'to better prepare engineering graduates for the real world of engineering'. Through the development of this degree program Chisholm has become a CDIO collaborator.

All Chisholm degree programs have been accredited by the Victorian Registration and Qualifications Authority. This body has now transferred its higher education accreditation to the newly established Tertiary Education Quality and Standards Agency - Australia's regulatory and quality agency for higher education. Thus, in compliance with the recommendations of the 2008 Bradley Report and the Federal Government's initial response, the Chisholm programs now fall under the Australian Government regulatory body – like all Australian universities – but without the associated Australian Government funding through the provision of Commonwealth Supported Places.

Background

At the start of the 1990's Michael Rice, a widely acknowledged expert in the field of Australian labour force supply and demand, predicted that 'Australia faces a future of scarcity in the primary intellectual resource upon which its industrial capability depends. Australia's biggest worry is not science, but engineering. The driving force in the infrastructure, utility and manufacturing industries is engineering.' (Rice, M.R. and Lloyd, B.E.1991).

[1] Chisholm also has the only two Advanced Diploma programs fully accredited by Engineers Australia at the level of Engineering Associate.

In his analysis he considered the recommendations for increased supply by the *Review of the Discipline of Engineering* conducted under the direction of Sir Bruce Williams (Williams, B. 1988) to be too optimistic. Williams recommended a target increase in engineers in active practice from between 0.84% to 0.90% of the Australian labour force (or between 62,700 and 67, 520) in 1986 to 1% (or between 92,000 and 95,000) by the end of the century. Rice's analysis indicated that to achieve that target annual graduations would need to increase from 3,500 in 1986 to 5,300 by the year 2000 and he determined that as part of achieving that goal, the participation of women students would need to increase from 7% to 20% and net immigration would need to add between 2,250 to 5,250 engineers to the stock of professional engineers by the year 2000. As this was shortly after a marked decline in completions between 1976 and 1981 this appeared unrealistic.

However a decade later on, Rice conceded that in his 1991 analysis he had significantly underestimated the growth in the professional engineering labour force (PELF). In 2001 he estimated the 2000 professional engineering labour force in 2000 to have been 147,000 (Rice, M.R. 2001a).

This unprecedented increase in the PELF was due to unforseen factors:

(i) In the decade 1988 to 1998 more than 23,000 engineers arrived in Australia as permanent settlers. Whilst at the same time there was also a marked increase in the number of Australian engineers departing permanently (approximately 4700), the net migration (over 18,000) was still far more than could have been anticipated.

(ii) In the period 1990-1998 there was an increase of 77% in the annual graduation rate. The main contributing factors were:
   a. A greater impact of their own proposed articulated pathways (Lloyd et al 1989) through the three year engineering technology degrees than they had imagined. By the end of 1999 19 university engineering schools offered a total of 50 separate engineering technology degree programs.
   b. The introduction of distance education for engineering and engineering technology degrees.
   c. A significant increase in university engineering schools and Engineers Australia accredited professional engineering programs. From 1980 to 2000 there was an increase from 26 to 35 engineering schools and 113 to 229 four year engineering degree programs.
   d. An accelerating proliferation of engineering undergraduate courses in specialist or hybrid areas.
   e. The proportion of female commencing students increased rapidly until 1992 when it hovered around 13 to 14% through to 2000. The highest proportions of female engineering students were in Chemical Engineering (35.7%) and 'other' 38.3%. ('Other' features the specialist or hybrid areas and includes materials and environmental engineering, both popular with female students.)

Over the subsequent decade to 2010 the local supply of engineering skills fell well short of demand. A survey by the Australian National Engineers Taskforce (*ANET Engineers Survey*, 2010) found that 60% of the individual engineers they surveyed said that they had a shortage of engineering skills in their work sections.

Due to many universities consolidating their engineering offerings to achieve cost savings, there are now only 31 Commonwealth supported engineering technology degree programs from a total of 13 providers. Through consolidation the range of engineering undergraduate courses in specialist or hybrid areas has also been significantly reduced. This may be a contributor to the current gradual fall in the proportion of female commencing students.

Australian universities currently produce around 6,000 domestic graduates (and 3,000 international graduates) annually comprising bachelor degrees, associate degrees and diplomas in engineering and related technologies (*The Engineering Profession – A statistical overview* 2010). Over the period 2001 to 2008 the average annual growth in the number of domestic graduates was only 1% whilst the graduation rate of overseas students grew by 11%. New Australian engineering graduates account for only 40% of total supply; migrant engineers account for 60% (*Towards a National Strategy for Migrant Engineers – a discussion paper* 2011). Engineers Australia recognises that a heavy reliance on migrant skills is not sustainable however they are investigating the reasons for significant underemployment of migrant engineers (ibid.).

Terms of Reference

This submission only addressed the following terms of reference:

The nexus between the demand for infrastructure delivery and the shortage of appropriate engineering and related employment skills in Australia, with particular reference to:

> (c) Options to address the skills shortage for engineers and related trades, and the effectiveness and efficiency on relevant policies, both past and present;
>
> (i) Other related matters.

(c) Options to address the skills shortage for engineers and related trades, and the effectiveness and efficiency on relevant policies, both past and present.

ci) The shortage of secondary school students with year 12 qualifications in the more difficult mathematics and physics subjects.

Dunn (2012) presents data prepared for the Sunday Age by the Victorian Curriculum and Assessment Authority which shows low and falling enrolments in the sciences and higher level mathematics (Mathematics Methods and Specialist Mathematics). However there has been a significant increase in enrolment in the easier Further Mathematics.

For many years most, if not all, university engineering schools have removed the previous requirement for physics and chemistry from their entry requirements because the low numbers who study these subjects at VCE would severely limit their enrolments. Currently in Victoria only 13.8% of secondary school students study physics and 17.8% study chemistry (ibid.). Instead the necessary content is now typically covered in 1st year degree subjects in both the 4 year engineering degree and the 3 year engineering technology degree.

The standard mathematics entry requirement for the 4 year engineering degree is Mathematics Methods and/or Specialist Mathematics. The current percentages of enrolled students in these two subjects are 31% for Mathematics Methods and 7.9% for Specialist Mathematics. Note that some students enrolled in Specialist Mathematics are also enrolled in Mathematics Methods so these percentages cannot simply be added together.

However mathematics entry into engineering technology programs is a minimum level of Further Mathematics. Further Mathematics has a current VCE enrolment rate of 58.4% so the restriction to entry due to the selection of a lower level mathematics in VCE is significantly reduced. It should also

be recognised that a student's selection of Further Mathematics may be due to lack of subject availability. The reduced mathematics entry level into the engineering technologist degree is compensated by the addition of a lower level mathematics subject to the degree program. Thus the engineering technology degree – which can articulate into the engineering degree – facilitates access for a much larger population base.

A major source of the problem with the teaching of mathematics as well as these two sciences at primary and secondary level is the scarcity of good teaching specialists in these fields – particularly in non-metropolitan regions. An early attempt at solving the problem was to offer incentives to encourage science and mathematics based professionals (mainly engineers) to study a postgraduate qualification in education to become a mathematics and science specialist teacher.

An alternative approach would be to create a national mathematics and science subject centre along the lines of the UK Higher Education Authority subject centres but focused on primary, secondary and tertiary education. Their directive would include sourcing and creating a library of the most effective teaching materials and organising subject conferences and workshops. The objective would be to support existing teachers of mathematics and science in the delivery of programs that will best engage and interest primary and secondary school students.

cii attracting and retaining students in engineering

There are several excellent and well established initiatives already in place to attract students to engineering (and science). These include the Engineers Australia engineer in schools program, the University Newcastle Science and Engineering Challenge, the Shell Questacon, and (for Victoria) the RACV Energy Breakthrough. In addition, UK produced engineering related television documentaries would also have an impact in attracting students to engineering. However apart from the decline in the study of mathematics and science at secondary school several underlying issues still adversely affect student choice of engineering as a career. These include:

- The 'British Malady' (Rice 2001b, pp.155-6) in which a confused image of the engineering profession is portrayed by the media - with the outputs of engineering often attributed to applied science. In Australia this confusion is further exacerbated by the frequent misuse of the title engineer by the media, and outdated images of manufacturing.
- Easier access to an increasing range of alternative professional career courses, and
- A public perception/awareness that professional engineering study is generally characterized by higher than average attrition rates.

Recognizing that engineering shortages are across the full engineering spectrum from the engineering trades to the professional engineer, another approach to increasing the overall engineering skills base is through linking the Lloyd et al. (1989) engineering pathway approach with co-location of the engineering technology degree program with the engineering trades and further education programs, and through well mapped articulation and guaranteed pathways between the programs. This can provide significant advantages at all levels through creating clearer pathways between the various technical levels. Students entering at trade level have the assurance of a clear pathway to the degree program should they wish, and those enrolling in the degree program concerned that they may find it too difficult have the assurance that they can articulate into a less academic program - rather than leave their engineering studies with nothing. This is the Chisholm model.

The UK concept of 'higher apprenticeships' - designed to meet employers' needs for higher level skills - will better support this model. Higher Apprenticeships provide better opportunities for high performing apprentices to combine on and off the job training in career pathways that will take

them right through to higher level roles and provide better opportunities to higher qualifications. They are also considered platforms to increase tertiary access for low SES groups.

(i) Other related matters: The implications of the shortage of high level technical skills on the manufacturing sector

Nationally the manufacturing sector remains one of the most important contributors to the Australian economy. Manufactured goods amount to around half of Australia's exports. Each job in manufacturing generates between 2 and 5 jobs in the rest of the economy.

But manufacturing is changing. Whilst the media has focused on the off-shoring of Australian manufacturing, particularly to China, this has been mainly high-volume low-cost low-skill manufacturing. However across Victoria, for more than a decade there has been strong growth in elaborately transformed manufactures (ETMs).

Between 1999 and 2008 export of products from Victoria's ETMs rose 42%. As a consequence there has been a rising share of higher skilled professionals within the manufacturing workforce with an increase in the proportion of managers and professionals from 20% to 30%.

Elaborately transformed manufacturing represents high value-added niche areas demanding high level technical skills. Examples include air traffic management systems to Asia, utility aircraft and missile systems to the US, and automotive instrumentation to Europe.

To remain competitive it is essential for companies to become increasingly efficient, innovative, minimise defects through effective continuous quality improvement, and use new technology to best effect. The implications for skill requirements are a need for higher level technical skills, a broader range of skills and the need to update skills more often. In consultation with regional employers, 80% felt that higher level technology skills would be increasingly required as product and manufacturing technology increased.

Engineers Australia and VECCI have indicated that many companies employ professional engineers in roles better suited to engineering technologists. Whilst there are similarities between degree programs for engineering technologists and professional engineers, there should be (but often isn't) a difference in focus. An engineering technologist program should focus more on technology and systems; whereas engineering programs have a greater focus on R&D and design. However shortages in engineering technologists are much greater than the shortage of professional engineers.

Recommendations

1 *In line with the Federal Government's initial response to the Bradley review, extend the Government funding of Commonwealth supported places to all domestic students accepted into TEQSA accredited public higher education Engineering Technology programs.*

This will assist in addressing the shortage of engineering and related employment skills by provide much greater access to fully accredited engineering technology and engineering degree programs delivered by public multi-sector educational providers. The result will not only be a significant increase in the supply of industry ready engineering technologists and engineers but through clearer articulated study pathways will improve the attractiveness of engineering careers at all levels.

2 *Develop an Australian model for Higher Apprenticeships using the UK model as a guide.*

3 *Establish a national mathematics and science subject centre focused on primary, secondary and further education. The directive would include sourcing and creating a library of the most effective teaching materials and organising subject conferences and workshops. The objective would be to support existing teachers of mathematics and science in the delivery of programs that will best engage and interest primary and secondary school students.*

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