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President
Dr Alan Finkel AM FTSE

Australian Workforce and Productivity Agency
Engineering Workforce Study Project Team

26 March 2014

Dear Sir/Madam

ATSE Submission: AWPA Engineering Workforce Study Issues Paper

The Australian Academy of Technological Sciences and Engineering (ATSE)[1] welcomes the opportunity to provide advice on key issues for the AWPA Engineering Workforce Issues Paper.

The submission focusses primarily on employment issues related to engineering bachelors degree graduates; engineering trade skills are not discussed. Over the last two decades there has been little national attention given to educational development and employment opportunities for engineering technicians and paraprofessionals.

Further, attempting to improve predictability of future discipline demand has proven to be ineffective, especially given Australia's low population and relatively small local market. As such, engineering degrees need to be positioned to be valued beyond employment prospects in specific occupations.

Engineering is important for a prosperous and sustainable future for Australia. Engineering helps create wealth from ideas and will be essential in solving problems in the future. ATSE has identified 3 National Technology Challenges for improving the quality and reach of science, technology, engineering and mathematics education at all levels:

- Improve STEM tertiary education, research and career training to meet future industry, social and economic needs
- Adopt effective pedagogies and educational practices within STEM education at all levels
- Support STEM secondary school teachers to improve teaching of STEM and STEM literacy

These National Technology challenges will be important in meeting Australia's future engineering skill needs.

The contact at ATSE is Dr Lauren Palmer (Senior Research and Policy Officer) on (03) 9864 0903 or via email at Lauren.Palmer@atse.org.au. The independent expert advice of the Academy is available to assist in further.

Yours faithfully

Dr Alan Finkel AM FTSE
President

[1] ATSE advocates for a future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing. The Academy is empowered in its mission by some 800 Fellows drawn from industry, academia, research institutes and government, who represent the brightest and the best in technological sciences and engineering in Australia. The Academy provides robust, independent and trusted evidence-based advice on technological issues of national importance. ATSE fosters national and international collaboration and encourages technology transfer for economic, social and environmental benefit.
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Submission by the

The Australian Academy of Technological Sciences and Engineering (ATSE)

to

Australian Workforce and Productivity Agency

Engineering Workforce Study Issues Paper

March 2014

Contact details:
Australian Academy of Technological Sciences and Engineering
03 9864 0900
policyresearch@atse.org.au

Australian Government

Australian Workforce and Productivity Agency

Submission to Engineering workforce study

Please email your submission to AWPA at **engineeringstudy@awpa.gov.au** by **26 March 2014**.

Contact information

Organisation: The Australian Academy of Technological Sciences and Engineering

Contact name:

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Email: policyresearch@atse.org.au

Publication consent

Do you provide consent for AWPA to publish the information provided in this submission in the Engineering workforce study final report and in other AWPA publications which may appear on the internet and in print, electronic or video media? *(Please tick)*

✓ Yes

Responses to questions for discussion

Please expand boxes as needed to fit your responses. You do not have to respond to all questions.

1. Are there engineering skills that are difficult to source? How do companies source these skills?

The nature of engineering practice is such that the widespread availability of advanced engineering and technological skills is likely to lag demand. This applies to all occupational levels, including engineering trades. New materials and processes, and new codes and standards (including safety) require individuals and companies to continually invest in skills and professional development.

Amongst professional engineering occupations and during the last decade, Australia has seen shortages of experienced systems engineers, software engineers, mining and construction engineers, and power systems engineers. Whilst deep experience is gained in employment, many companies recruit and value graduates for their knowledge of and aptitude with new software tools. Otherwise, companies may source skills by immigration, recruiting from each other, or may partner with each other for major contracts to retain specialised skills within consortia.

2. What are some best practice approaches by companies to develop skills that are not readily available?

Global companies are likely to develop skills of their more senior Australian-based engineers off-shore. Within Australia, there is vigorous, market-driven short course provision in areas such as project management, maintenance management, and process automation. Most participants in such

programs would be sponsored by their employers, and may be provided with flexible workplace arrangements to study. There are many graduate programs that also help develop a range of skills that are not necessarily dealt with at the undergraduate level, such as business acumen, human factors, specialised engineering skills, and large scale systems integration and optimisation. The announcement in 2013 of the John Grill School of Project Leadership at the University of Sydney is an example of a recognition by business of the importance of such programs for both engineers and business graduates.

Whilst there are postgraduate programs and short courses to enhance graduate skills and attributes, the real demand for such courses is much less than the expressed demand. Company specific courses do feature and can provide incentives for universities if there are companies seeking to get an advantage over their competition.

For areas of shortage referred to above, and where the academic expertise is also thinly spread, companies and universities have formed consortia to deliver effectively "national" bachelor degree programs. Two standout examples are Mining Education Australia, and the Australian Power Institute. These programs offer scholarships to students and good workplace integrated learning. Australia's defence industry has developed advanced capability in systems engineering through postgraduate courses and research with several universities (e.g. The Defence Systems Innovation Centre).

3. What inspires students to study engineering? What are some innovative approaches to promoting engineering careers?

Numerous studies have found that young people are attracted to studying engineering at university because they enjoy problem solving and design; applying their skills in practical ways; have an interest in new and emerging technologies; and are inspired by its good career prospects. Promoting the humanitarian, social and environmental goals and the variety and diversity of options in engineering can also increase participation rates. For more than a decade, about 5.5% of all domestic commencing university enrolments have been into engineering degree programs[2]. Within this aggregate there was a recent shift towards civil engineering (now graduating approximately one-third of all bachelor level graduates), while electrical and electronics engineering graduations have declined. Such change illustrates prospective students' responsiveness to perceived graduate employment prospects. Family members are also significant influencers: women are more likely to take engineering if they have an engineer in the family[3]; for many recent immigrants, engineering is a preferred degree choice to arts or science. Within the engineering disciplines, Environmental, Biomedical and Chemical Engineering attract higher female participation rates.

Increasing the opportunities for applied learning pathways in year 10-12 can assist keep young people engaged in engineering. Awareness of engineering - and its connections to science and (less) to mathematics - in schools have been strongly promoted by many activity-based programs, including ATSE's STELR Project[4], referred to in the Issues Paper. There is initial evidence that such programs are increasing students' interests in continuing senior science study. However, the ability of schools to provide high quality teaching at that level, and continue their students' interests into university science and engineering, is compromised by the national lack of well qualified teachers in these areas. Whilst there are too few teachers with science qualifications, there are even fewer with engineering qualifications. ATSE has published recommendations on this area in its STEM Education Action Statement[5].

[2] Data from the Australian Council of Engineering Deans

[3] J Mills, M Ayre and J Gill, *Gender Inclusive Engineering Education*, Routledge, New York 2010

[4] The Science and Technology Education Leveraging Relevance (STELR) Project is a national secondary school science education initiative of the Australian Academy of Technological Sciences and Engineering (ATSE). Further information can be found on the STELR website - http://stelr.org.au/

[5] ATSE, Advancing Science, Technology, Engineering and Mathematics Education, ATSE Science and Technology Action Statement, September 2013, http://www.atse.org.au/Documents/Publications/science-technology-action-statement.pdf

Over recent years, there has been some incorporation of engineering into mainstream media in the form of documentaries. Further, integration in TV shows and movies showing the human side of engineering would lead to greater awareness in the community of what engineers do.

4. How can career counselling services be supported to deliver current and accessible information about engineering to school students?

Anecdotally, some careers counsellors feel overwhelmed by the amount of information about engineering that they are sent. Whilst the wide range of possible engineering careers, including in engineering trades, cannot be denied, a more coordinated (and less competitive) national approach to the provision of information could be envisioned. AWPA would be ideally placed to initiate such an approach, with its constituent bodies, plus Engineers Australia, ATSE, and others.

5. What can be done to build on the increasing supply of engineering graduates to ensure that problems of engineering skills shortages do not recur in the future?

As reported in the response to Q3, overall student demand for engineering degrees has been steady as a proportion of overall commencing enrolments, with variability in the choice of branch that reflects current graduate demand, rather than the future employment cycle. Attrition rates have tended to decline in most universities, with improved first-year curricula and student support[6]. Australian universities provide a very wide range of engineering degrees and pathways, including a number of 5-year BEng-MEng and double bachelors degree models, and distance education models, taken mostly by mature students. All engineering students graduate with a specialisation in one or more branch of engineering: there are few employment opportunities for graduates without having any such identity. Nevertheless, once in employment, engineering graduates are able to traverse other engineering branches and can undertake a wide range of roles.

The anticipated demise of automobile manufacturing (albeit a small component of the manufacturing sector), uncertainties about physical infrastructure investment, and the current position on resources cycle may result in universities reporting lower commencing enrolments in 2014. However this may turn out to be a very good year to be a commencing engineering student, if the current employment trends reverse (see Q6).

A challenge for the university system is to more explicitly position engineering as a degree of value beyond its employment prospects in specific engineering occupations. The degree could be so positioned, at least by some university providers, by emphasising more strongly the contextual dimensions (environment, economy, and socio-cultural) and integrative elements (systems thinking, risk assessment and project management) of engineering practice. Other universities might more strongly encourage linkages with their courses in "design, innovation and creative industries" that paradoxically are not seen to be intrinsically associated with engineering.

6. What are the engineering skills needs of the future in Australia? How will Australia meet these needs?

ATSE cannot envisage a prosperous and sustainable Australia without enhanced engineering capabilities. ATSE has demonstrated needs and opportunities in several papers and workshops; *Green Growth Energy*[7], *Smart Technology for Healthy Longevity*[8], *Drinking Water Through*

[6] E Godfrey and R King, *Curriculum Specification and Support for engineering education*, 2011, http://www.olt.gov.au/project-curriculum-specification-support-uts-2008

[7] ATSE, *Green Growth Energy: Industry Opportunities for Australia,* 2013, http://www.atse.org.au/atse/activity/energy/reports/atse_green_growth_report_2013/content/activity/energy-content/atse_green_growth_energy_report_2013.aspx

Recycling[9], *Sustainable Water Management*[10], and *Food and Fibre - Australia's Opportunities*[11]. To that end ATSE has identified seven areas of National Technology Challenges, covering innovation and productivity, energy, health, agriculture, natural resource management, infrastructure, and education. These challenges will not be met without a strong body of capable and innovative engineers and technologists.

Most engineers and technologists will be faced with human dimensions of work, such as industrial relations, and the interplay with local communities on development and environmental issues. They will need to work in teams with professionals from a wide range of disciplines, including the humanities and social sciences. Interdisciplinary training is vital for the challenges Australia faces. Systems thinking and the ability to work effectively across discipline boundaries are valued characteristics in graduates and employees.

Nevertheless, Australia's small population and location mean that we have to live with fluctuations in demand for engineers. ATSE is providing project services on behalf of the Australian Council of Learned Academies, on Project 4 of the Securing Australia's Future research program. The project, *The Role of Science Research and Technology in Lifting Australia's Productivity*, is identifying opportunities for applying knowledge and skills in science and research across a range of industries and sectors including private and public enterprises, and examining how to enhance innovation, creativity and productivity through the workforce and business practices that will drive Australia's prosperity.

The case of prospective large infrastructure requirements in mining and energy is instructive. Mining typically occurs in remote areas and future mining infrastructure requirements will be enormous, running the full spectrum of engineering disciplines. In energy, shale gas will become an important new energy source requiring infrastructure for extraction and delivery (including pipeline infrastructure and port expansion). For the development of both sectors, Australia will need a diverse and flexible engineering workforce and a wide range of professionals from the humanities and social sciences.

In other areas, such as health, agriculture, and advanced manufacturing, engineers need to be able to work effectively across and with other disciplines. It will be important to have a coordinated approach to examine the whole skill base needed for future industries in the development of a future workforce plan. Developing a subset of graduate attributes in engineers such as developing cultural awareness, understanding of a social license to operate and how industrial relations work, needs to be more strongly integrated into the curriculum.

ATSE has identified three areas for action in education that are consistent with other parts of this response:

- Improve STEM tertiary education, research and career training to meet future industry, social and economic needs;
- Adopt effective pedagogies and educational practices within STEM education at all levels;
- Support STEM teachers to improve teaching of STEM and STEM literacy (see Q3).

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[8] ATSE, *Smart Technology for Healthy Longevity*, 2010 http://www.atse.org.au/Documents/Publications/Reports/Health%20&%20Tech/Smart%20Tech%20for%20Healthy%20Longevity%20-%20Report.pdf

[9] ATSE, *Drinking Water through Recycling: The Benefits and Costs of Supplying Direct to the Distribution System*, 2013, http://www.atse.org.au/atse/activity/water/reports/content/activity/water-content/drinking-water-through-recycling.aspx

[10] ATSE, *Sustainable Water Management: Securing Australia's Future in a Green Economy*, 2012, http://www.atse.org.au/Documents/Publications/Reports/Water/ATSE%202012%20Sustainable%20Water%20Management%20REPORT.pdf

[11] ATSE, *Food and Fibre: Australia's Opportunities*, April 2014

7. Are there industry committees collaborating with universities in developing engineering curriculums? How do these work and what have been some of the outcomes?

The 35 universities that offer engineering degrees (mostly BEng, BEng(Hons) and MEng) that are accredited by Engineers Australia are required to demonstrate that their programs contain "exposure to practice", and also that they have an industry advisory processes to advise on the curriculum. Whilst performance is variable, these processes have contributed to improved work-integrated learning (WIL) (e.g. within industry capstone projects), guest lecturers (e.g. for project management and the contexts of engineering practice), and improved awareness of the constraints under which universities operate.

Formative engineering education has also been subjected to national reviews in 1995-6 and 2007-8 in which ATSE has been involved. These studies have systematically involved practicing engineers. The outcome of the 1995-6 review, *Changing the Culture*, led to the adoption of an outcomes-based accreditation system, with greater focus on student-centred, active learning. The 2007-8 report, *Engineers for the Future*, reinforced these points, and the need for closer collaboration with industry. The latter study was funded by the Australian Learning and Teaching Council (now the Office of Learning and Teaching). Since 2008, these bodies have funded many collaborative projects in WIL and for improvements in engineering education in the university sector. There appears to have been a marked absence of parallel studies on teaching and learning in the VET engineering sector.

8. Are there sufficient work-integrated learning opportunities for engineering graduates? How can smaller companies be supported to provide entry-level opportunities for graduates?

This question has several dimensions. Taken literally, 'work-integrated learning for engineering graduates' is about learning opportunities for graduate employees. Most larger engineering companies have good graduate development schemes; in smaller companies graduates gain experience 'on the job'. The second part of the question implies that too few smaller companies take on graduates. Irrespective of the employment cycles, an underlying issue is that much of the engineering work undertaken in Australia is project-based, and graduate training would be viewed as an unfunded overhead. That said, employers would value good practice guides to assist them to utilise graduates effectively and also enrich the graduates' experience.

The availability of good quality WIL for engineering students varies widely. It is well established that a good internship experience can be positively transformational for development of engineering thinking and personal skills development. A poor experience may be worse than none. It is also important for graduates to gain experience in industry, however many employers do not know what this experience should be, and how it should be managed. Promulgating best practice is referred to later in this response.

All of the 35 universities that run professional engineering degrees (mostly BEng, BEng(Hons) and MEng) that are accredited by Engineers Australia have a 12-week (or more) workplace requirement within their degree regulation. A small number of universities have more extensive co-operative arrangements. All BEng/BEng(Hons) students at the University of Technology, Sydney are required to take two long internship periods (plus pre-view and post-view), for which they may be awarded a Diploma of Industry Practice. Longer internships are operated by some other universities. Almost every engineering faculty has a prestige WIL program for selected undergraduates (see Q9).

Providing good quality 12 week internships for more than 11,000 pre-final year students (one third of who may be international) is a severe challenge for both engineering schools and industry. There is normally no Commonwealth funding (for domestic students) for this model of WIL.

The Australian Council of Engineering Deans (ACED) is currently conducting a major project (involving 12 engineering faculties) on improving students' exposure to engineering practice, with

funding from the Workplace Innovation Program. As well as internships, this project is piloting bringing some "industry-inspired projects" into the middle curriculum years. This is where often the connections between the engineering science being taught is perceived to be remote from engineering practice. The project will provide a good practice guide, exemplars of good practice, and recommendations for the universities, industry, government and professional bodies in its final report in June 2014. One recommendation will be to establish state-based coordination/brokerage of placements, with more standardised expectations of employers and students.

ATSE also welcomes the recent announcement of collaboration between Universities Australia, the Australian Industry Group, the Business Council of Australia, the Australian Collaborative Education Network Limited, and the Australian Chamber of Commerce and Industry, on enhancing WIL, especially for students in STEM degrees. WIL works best when collaboration with specific enterprises is not an add-on for the school/faculty but is a foundation for their research and teaching programmes. It is also important when the WIL is value adding for the enterprise and not seen as a philanthropic cost.

9. What works well in effective work-integrated learning programs?

As noted above, there are some stand-out examples that will be reported as examples of Best Practice in the forthcoming ACED study report. Underlying the success of WIL are strong relationships between the company and the university; clear goals and expectations by all stakeholders; and good student supervision (or mentoring) by the company.

An example of good practice is the Major Industry Projects Placement Scholarship (MIPPS) program at the University of Sydney, where students are offered the opportunity to complete a research project whilst placed in industry for a semester. The program is in its 14th year, with some companies having participated every year. Further examples include the Corporation Technologies (CEED) Program and the University of Queensland Integrated Masters Program. The CEED program is an industry-based training program for final year and Masters students that links them with industry based projects. The CEED program has many university partners nationwide. The University of Queensland Integrated Masters (Bachelor of Engineering Masters of Engineering) program is another example and has a compulsory semester-long industry or research work placement component.

Industry employed people holding adjunct or visiting positions can be highly valuable in terms or ensuring relevance, if they are the right type of people and it is managed properly. Industry adjunct or visiting positions could be established through reengaging alumni. Whilst this is a relatively small administrative burden, it is a useful adjunct to WIL.

10. What are your views on engineering graduates not working as engineers?

Engineering work itself is very broad, embracing technical, research, and managerial functions. The professional engineering degree is well proven to be a good basis for employment in quantitative project-based work including in managerial and financial sectors. Employment opportunities in these areas are likely to be enhanced for the 25% of BEng graduates from “combined”, “double”, or “dual” degree programs, many of which are taken with business, management or commerce.

The careers of most engineering graduates develop through technical work towards increasing management responsibilities. The bulk of detailed technical work is undertaken by young and mid-career professional engineers and in paraprofessional occupations. Stronger opportunities are needed for career advancement for engineers in specialised technical functions.

Having a wide range of employment opportunities for engineering graduates should be advertised and celebrated, not least by senior leaders in business and the community who have

engineering degrees.

11. What strategies exist to improve communication and dissemination of information about existing VET articulation pathways into higher education? What are the outcomes of these strategies?

As the Issues Paper observes, the numbers of students graduating with Diplomas and Advanced Diplomas in engineering is very low, severely restricting the pool for these articulation pathways. A much more populous pathway is articulation from degree completion to VET for specific certificate courses in areas such as project management.

ATSE is aware that all universities have pathways for VET graduates, particularly from Diplomas and Advanced Diplomas, to undertake degrees. Some universities have quite a high proportion of commencing students starting degree studies with advanced standing from their VET studies. As many of these students are in full-employment (e.g. as technicians, technical officers, and engineers) the progress towards their degree may be slow.

12. Is there a demand for engineering paraprofessionals? How can this demand be addressed?

"Paraprofessionals" occupations nominally require AQF Level 5 - 6 (Diploma, Advanced Diploma and Associate Degree) qualifications. We suspect that many who now occupy paraprofessional roles in industry have lower level qualifications, and have earned promotion through experience and short courses. They are likely to be technically-expert hands-on managers of drafting, production and maintenance. The demands for and on these roles is likely to increase in technical intensity (e.g. in automated systems), while the pathways to them have become less clear, as university participation has grown, and the technical capabilities of the VET sector (for Levels 5 - 6) have shrunk with decreasing demand. ATSE would suggest that there is a need, in Australia, to have a detailed study on paraprofessional occupations and the education pathways to them.

We also suspect that companies place graduates with professional engineering degrees in these roles, where they may feel dissatisfied by both being "over-qualified", but "under-prepared". The dissatisfaction brought about by these mismatches may lead to early attrition from engineering.

In addition, there needs to be further study of the occupational roles for 3-year qualified graduates in engineering, currently badged as "Engineering Technologists" by Engineers Australia. Australia currently has a small number of graduates from this qualification, and many find it hard to secure employment. It could be argued that there will be meaningful future occupations that require a reconceived 3-year degree, than 4- or 5-year professional engineering degrees. There would be cost benefits of having a stronger 3-year engineering qualification to students and governments, if employers were able to define suitable roles within their organisational structures. Such a degree would also put one engineering study pathway on a par with the basic Australian 3-year BSc.

13. What are your views on labour market outcomes for skilled migrant engineers?

The Australian university and research system relies very heavily on migrant engineers. More than 50% of engineering PhD graduates are international students and a high proportion of engineering academics are sponsored migrants. They bring international networks, as well as their own expertise. However, it is becoming more difficult to recruit and retain good engineers from overseas, as opportunities and salaries in their home countries have improved, and immigration procedures remain difficult.

14. How are workplace family-friendly policies used by engineering employees?

This is an important question; however ATSE does not have any further comments to provide at this stage.

15. What are your views on the availability and take-up of part-time and job-share opportunities in the engineering workforce?

This is an important question; however ATSE does not have any further comments to provide at this stage.

16. What effective strategies do companies have in place to support and retain mature-age engineers?

This is an important question; however ATSE does not have any further comments to provide at this stage.

17. How can lifelong career guidance services facilitate mid-career entry into the engineering workforce?

This is an important question; however ATSE does not have any further comments to provide at this stage.

18. What pathways are available for mature-age engineers to re-enter the engineering workforce?

This is an important question; however ATSE does not have any further comments to provide at this stage.

19. What are some best practice approaches to improving the participation of Indigenous Australians in higher education engineering courses?

The number of indigenous Australian school leavers with pre-requisite study in physical sciences and mathematics is extremely low. ATSE encourages the work of the Australian Indigenous Engineering Summer School, and Australian Indigenous Mentoring Experience to promote engineering opportunities to indigenous school students.

Do you have any other comments on the issues raised in this paper?