Australian Council of Engineering Deans

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SUBMISSION TO THE HIGHER EDUCATION REVIEW

from the
Australian Council of Engineering Deans

Authorised by ACED President: Professor Elizabeth Taylor AO

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INTRODUCTION

The Australian Council of Engineering Deans (ACED) comprises the leaders of Australia's university-based engineering faculties and schools.

In 2006 these engineering schools awarded approximately 8,000 bachelors degrees and other undergraduate awards, 3,400 postgraduate coursework awards, and 845 masters and doctoral research degrees. The international proportions of these graduating cohorts were 28%, 75% and 31% respectively. In total, engineering schools produce approximately 8% of all university graduates.

During 2007, ACED reviewed the position of engineering education and scoped emerging issues. The project was undertaken in partnership with the professional body, Engineers Australia, the Australasian Association for Engineering Education (AaeE) and the Academy of Technological Sciences and Engineering (ATSE), with funding from the Australian Learning and Teaching Council (ALTC). The report [1] was completed in March 2008, and includes a vision and set of recommendations for future action. The vision has engineering education and research as strong elements of Australia's higher education and innovation systems. ACED also envisions that there will be greater sharing of educational materials and program delivery between the engineering schools.

This submission draws on the findings and directions of the recent review, providing comments and evidence related to questions posed in four sections of the Discussion Paper.

LABOUR MARKET AND INDUSTRY NEEDS

Engineering skills contribute directly to Australia's economy, environment, security and health. There is a current reported shortfall of some 30,000 engineers [2] – about 15% of current numbers – to undertake *known or available* engineering work. Australia has fewer engineers per population than broadly comparable countries, such as Canada. Economists, including the international development expert Jeffrey Sachs, have commented that it will be *innovation* and *adoption* of new technologies for energy and transport that will contribute most to Australia's response to climate change [3]. The demand for engineering graduates and experienced engineers is thus expected to increase in the coming decades.

Engineering education operates at all levels of the higher education system, and in all types of institution. The generic first-degree for entry to professional engineering is the Bachelor of Engineering award normally of four years' duration, consistent with current international standards. Several engineering schools also offer 3-year Bachelor of Technology awards, the entry qualification to the engineering technologist occupation. Some schools also offer Associate Degrees that may qualify their graduates to commence work as engineering officers. Professional accreditation of engineering programs at all three award levels is undertaken primarily by Engineers Australia.

All professional engineering degree programs include extensive project work that is usually industry and/or research-related. Honours is awarded to graduates achieving superior levels of attainment. Such honours classifications are highly regarded by industry, as well as being necessary for entry to research degrees. In Bologna process terms, Australia's professional engineering program structure is equivalent to a first cycle award of four years' duration. Our second cycle masters award would normally be awarded after a further three semesters of study.

Question 2: innovation in programs and courses

Over the past decade, engineering schools have been innovative and responsive to students' needs, while meeting the requirements of industry and the professional accreditation body. The latter's accreditation process focusses on *graduate outcomes* (rather than auditing content) and encourages innovation. A number of alternative program structures and pedagogical approaches now operate accredited programs across the wide range of engineering sub-disciplines. Since the previous mid-1990's national review of

engineering, *Changing the Culture* [4], there has been greater curriculum emphasis on sustainability and management, and increasing use of problem-based and project-based learning. Employers report (ref 1, p 67) that today's graduates have better skills in team-work and communications (other than in report writing) and in using software-based tools (both generic and engineering-specific) than previous generations.

The engineering schools offer many extended-duration pathways for the professional engineering qualification. These have mostly arisen from engineering schools' desire to increase (or maintain) student demand, or in response to industry. Approximately 20% of the 2005 graduates were reported as "graduating from programs longer than 4 years duration" (ref 1, Table 6). These extended patterns of study include:

- double, combined and dual degree programs that combine study of the engineering award with a science, management, law, or arts award, and thus extend or broaden the graduates' knowledge, understanding and skills. Many of Australia's most able students take these programs;
- programs that include extensive, monitored industry placements, and may lead to additional awards, or give credit for defined industry-based competencies that are otherwise acquired after graduation;
- integrated and articulated masters programs, in which the qualifying masters award is built on three years of prior study to a bachelor award level. The number of these programs appears likely to increase for a number of reasons, and has the potential to increase the production of professional engineers. Specific bachelor awards may be designed to be accredited at the level of engineering technologist.

ACED does not see that there have been system-wide and fundamental impediments to innovation in programs and courses. Educational innovation has been constrained, however, by declining resources and institutional prioritisation on research. The review reported considerable curriculum innovation (ref 1, pp 70 -76), and more is envisoned. The review (ref 1, pp 81-82) also referred to the value of making greater opportunities for engineering students to study alongside those of other disciplines, particularly in business and science, in order to develop new skills for innovation and problem solving for climate change, for example.

ACED would wish to minimise the barriers between inter-institutional working for course development and sharing of delivery, to maximise the productivity of the available expertise (see examples below).

<u>Questions 3 and 4: skills needs and supply and demand</u>

Current first-degree domestic graduations cannot meet projected needs. As a proportion of all domestic commencing enrolments, those into engineering fell from 6.1% in 1996 to 5.4% in 2006 (ref 1, p 33, DEEWR data). The most critical *educational supply* factor is the undersupply of school leavers who are *qualified* by their school subject choice and attainment to commence engineering studies. Increasing the number of places for undergraduate engineering does not directly increase that pool. ACED would support new measures in the school education sector to increase the numbers of school students attaining high levels of achievement in mathematics and sciences.

All engineering schools, and Engineers Australia and ATSE, are active in outreach to secondary schools to increase the visibility and positive perceptions of engineering study as a means to *expand* career opportunities, using the evidence of the generic attributes of engineering programs, and the successes of individuals in a wide range of occupations. Intensifying and expanding the outreach activities to *motivate* more school students to consider higher education study in engineering (and take the right qualifying school subjects) is part of the first recommendation of the recent review.

The alignment between higher education program pricing and labour market demand appears to be a weak driver of student demand since this would tend to come into play after school subject choices have been made. It would be counter-effective, however, to price engineering programs higher than science or other quantitatively intensive areas, as these are all in demand and all draw on essentially the same school-leaver pool.

ACED is also well aware that the attrition from engineering programs is higher than desirable. On average 54% first-degree commencers graduate from their chosen program. ACED is concerned about the impact of increasing student costs and post graduation debt on learning and progress. Many students are undertaking too much paid work during study periods, decreasing their academic performance, and potentially increasing attrition rates. Cost s and debt may also impact on student decisions not to pursue higher degrees (see below). ACED has included further work on understanding the dynamics of attrition, as well as improving relevant curriculum design and delivery, in its recent project proposal to ALTC.

Question 5: responsiveness to specific industry skills needs

Engineering schools have been responsive to industry sector needs for supplying greater numbers of graduates, particularly when the relevant industry sector has provided incentives and resources. We quote from two examples from the review (ref 1) in areas where the market demand for engineers has failed to attract new students sufficiently rapidly. Both involve institutional partnerships with an industry body.

> The minerals sector formed the Minerals Tertiary Education Council in 1999, and created Mining Engineering Australia in 2007 as a consortium of the three major mining education providers (Curtin University of Technology, WA School of Mines, the University of Queensland and the University of New South Wales). The MEA provides a common 3rd and 4th year curriculum "to rationalise and improve teaching of mining engineering by coordinating resources to create a sustainable environment for the teaching of mining engineering".
>
> http://www.mea.edu.au/
>
> The Australian Power Insititute is a not-for-profit national organization established by the electricity power industry to boost the quality and numbers of power engineering graduates. During 2007-8 the Institute is working with the University of Technology Sydney, Curtin University of Technology, the University of Tasmania, Queensland University of Technology, the University of Queensland and Central Queensland University (via the Power Engineering Alliance, Queensland), the University of Wollongong and Victoria University.
>
> http://api.edu.au/

Question 6 and 7: responding to demographic change and skills upgrading and the UK paper

Many Australian graduate engineers advance their careers in project management, engineering management and general management, often after taking MBA or other postgraduate management programs. Australian graduates and most of the engineering industry do not generally utilise the high levels of expertise in the engineering schools in career development for their employees. As reported earlier, 75% of postgraduate coursework awards in engineering are taken by international students.

The defence industry, however, has found partnering with universities to be an important way of upskilling their professional workforce. The review (ref 1, pp 51, 52) provided two examples, summarised overleaf. As high-level upskilling programs these do not contribute directly to the fundamental problem of increasing the number of entry-level graduates in engineering.

To address this core issue the recent review recommended development of new engineering pathways and awards to assist and *fast-track re-entry* into practice (eg women wishing to return after child-rearing), *support qualifications upgrading* (eg by engineering officers and technologists, or immigrants with non-accredited qualifications), and *support rapid acquisition* of engineering qualifications by graduates of cognate disciplines. A number of such masters level programs are already under development. As this is

a matter of national priority, consideration should be given to additional commonwealth funding for such initiatives. ACED also strongly supports working more closely with the VET sector to provide sound articulation pathways into higher education awards (see below).

The Defence Science and Technology Organisation (DSTO) Continuing Education Initiative commenced in 2002 as a program of part-time postgraduate study in a selected range of scientific and technological disciplines that lead to a postgraduate award, or staff may opt for individual courses. Several hundred employees have now undertaken courses within the program. The program involves several universities, and is managed and administered under contract to DSTO independently of the individual program providers, by a consortium of the three public South Australian universities and AITEC Pty. Ltd.

www.aitec.edu.au/cei/

Under its Skilling Australia's Defence Industry (SADI) initiative the Commonwealth government is supporting defence industry companies, including small and medium sized enterprises (SME's) to partner together and with universities to have specific postgraduate award programs delivered to employees usually on-site. A notable feature of one such program, the M.Eng.(Military Systems Integration) at the University of South Australia, is that it caters for staff of three potentially competitive defence companies.

www.defence.gov.au/dmo/id/sadi/index.cfm

Question 7: the UK paper, Higher Education at Work

The issues raised and suggested solutions offered in the UK paper appear to be highly applicable to the Australian situation. Indeed some of the proposals, such as increasing the cooperation between industry and the engineering schools through more joint industy-university appointments are included as recommendations of the recent review (ref 1, p 110). It is worth adding that there is already close cooperation and sharing of information with the UK on engineering qualifications and accreditation, through Engineers Australia's membership of the Washington and Sydney Accords [5], and the close working between ACED and Engineers Australia.

ACED recommends:

- **that federal and state governments take urgent steps to increase the take-up of intermediate and advanced levels of mathematics and some science in their secondary school certificate studies;**
- **funding and regulation must minimise the barriers between inter-institutional working for course development and sharing of delivery, to maximise the productivity of the available expertise**;
- **that student fees for engineering are priced at the same level as those for science;**
- **that additional commonwealth funding be made available for new program and pathway initiatives for upskilling in critical areas, such as engineering .**

THE STUDENT EXPERIENCE OF HIGHER EDUCATION

Question 12: measuring the student experience and the effect of declining staff-student ratios

ACED considers that the student educational experience needs to be measured over a range of time-scales and span individual courses as well as whole programs. Graduates' perceptions of what aspects of education are most highly valued are known to change in the years after graduation. Longitudinal studies of graduates' perceptions 1, 5 and 10 years from graduation in professional disciplines, such as engineering, would have potential value to program designers.

The recent review (ref 1, p 43) commented that the nationwide average staff: student ratio in engineering has worsened from about 1:14 to 1:21 over the decade to 2006. Technical staff numbers have declined markedly over the decade while student numbers have increased. In addition, students and industry participants expressed specific concerns about the state of some laboratories, with regard to the age, applicability, maintainability and availability of critical equipment. Employers expressed concerns about programs adopting excessive use of computer simulations, and some students expressed concern that they had neither seen a good quality working laboratory-scale nor a full-scale version of a system fundamental to their discpline. The importance of having good quality laboratories and technical staff dedicated to engineering education cannot be overstated. The review received comments that facilities in many other countries are considerably better than ours. Several of the recommendations of the review are aimed are rectifying these problems, with industry and the profession willing to provide leadership of a *national solution* to the problem of re-equipping engineering laboratories to the highest international standards.

The declining resource base also makes Australia's engineering schools *less attractive* for talented academics and potential academics. Engineering education and research operate in competitive international markets, and many emerging economies in our region are offering good opportunities, not least for *their* returning nationals. The current funding levels for engineering schools threaten Australia's ability to maintain its current international position as a strong provider of both engineering education and research.

Questions 13 and 14: measuring the quality of learning outcomes and national and international benchmarking

The Engineers Australia accreditation process assesses programs against the delivery of graduate attributes, the educational environment and the quality systems used to ensure program delivery. The graduate attributes are also elaborated in the accreditation system as *professional competencies* that may be used for program design. The real test of the learning outcomes for most graduates will be their fit to employers' requirements, and the rate at which they can progress through work-place experience to gain the required competencies for practice as independent professionala and gain full Chartered status, ideally about five years from graduaiton. Having employers and graduates involved in the post-graduation rating of the learning experience would appear to have merit.

Several engineering school operate national and international benchmarking schemes, including forms of external examination and moderation of materials, such as project reports. Furthermore, the Australian accreditation processes are benchmarked formally as producing "substantially equivalent" outcomes as those of the other 12 signatory jurisdictions of the Washington Accord (for professional engineering qualifications) and the six other signatory jurisdictions of the Sydney Accord (for engineering technologist qualifications). (The basic purpose of the accords is to facilitate engineering graduate mobility through international recognition of awards gained in other signatories' jurisdictions. Washingon Accord signatories include the national accrediting bodies of USA, Canada, Japan, Korea, UK, Hong Kong as well as Australia.) Each accord has developed a set of program outcome standards (otherwise called *graduate attribute exemplars*) that are reviewed periodically by the accord signatories to ensure that they are in step with on-going changes to national higher education systems. The accord

standards and processes demonstrate a powerful means of international benchmarking of professional qualifications.

ACED recommends:

- **consideration of the development of longitudinal studies of graduates' perceptions 1, 5 and 10 years from graduation in professional disciplines to inform how perceptions change over time;**
- **consideration of having employers involved in the post-graduation rating of the learning experience;**
- **the formal benchmarking system as operated by the International Engineering Alliance to other professional areas;**
- **measures are taken to increase the unit of resource to engineering schools to ensure that Australian engineering programs can continue to operate at standards equivalent to the highest international standards.**

CONNECTING WITH OTHER EDUCATION AND TRAINING PROVIDERS

Questions 15 - 17: movement between VET and higher education

ACED has a strong interest in good connections with VET institutions, and in effective articulation of VET graduates into higher education programs. Some students consulted in the review (ref 1, p 77) who had articulated from TAFE institutions commented that the competency-based unit approach is not a good preparation for curriculum-based higher education study particularly in mathematics and science courses. Engineering academics endorsed this view, and also observed that students articulating from VET are often highly motivated and have greater practical knowledge of materials, instruments and systems that puts them at an advantage in other courses.

ACED has a strong interest in ensuring that the growing demand for engineering graduates at all levels is met by appropriately educated and trained people. The distinctions between the required outcomes at each qualification level do require different educational approaches, and we see value in having distinct sectors. On the other hand, there would be merit in allocating additional funding to dual sector institutions to support articulation and to develop *combined resources* (staff and equipment) to more effectively support engineering education at all levels. Different sectoral funding models should not be an excuse for poor utilisation of resources, particularly if they are co-located.

ACED recommends:

- **that funding models and regulations between the HE and VET sectors are designed to gain maximum productivity from available resources providing for engineering education programs at all levels in both sectors;**
- **that consideration be given to providing additional funding to dual-sector and other institutions to promote articulation pathways in engineering.**

HIGHER EDUCATION AND THE NATIONAL INNOVATION SYSTEM

ACED takes the position that undertaking research must be part of the mission of all engineering schools in the higher education sector. The review (ref 1, pp 89-91) commented on the importance of developing

public understanding of the role of engineering in innovation and the economy, and proposed relevant actions in its recommendations.

The current situation in which research productivity is expected but is not explicitly or adequately funded in engineering schools needs to be rectified to *intensify* the research-teaching nexus, and *maximise* research productivity *and* teaching outcomes. The review (ref 1, pp 43-46) found that the recent trends in research activity growth has been in centres and institutes that operate independently or at arms length from their "host" engineering schools and faculties. Of considerable concern, also reported in the recent review, was the declining numbers of domestic enrolments into research degrees. Such trends may severely threaten Australia's future capacity to contribute adequately to innovation-led industry, as well as sustain the academic workforce. ACED's submissions to the National Innovation Review (NIR) and the House of Representatives Inquiry into Research Training and Research Workforce Issues provided extended comments on these matters, and the first two questions posed here.

Question 19: supporting research

The current system of support lacks both transparency and arguably, fairness. Research, in a broad sense, is undertaken by most engineering academics in teaching and research positions. Only some of this may be accounted under the present arrangements.

The engineering review (ref 1, p 107) recommended undertaking work to increase the focus and dissemination of *engineering education* research, and the need to make the curriculum *more authentic* with respect to industry practice. The latter work is time consuming and analytical, but may not be conventionally publishable. The current national research measures, as used for research infrastructure and research training allocations, are too narrowly focussed to recognise and consequently provide direct incentives for such vital activities that support improved pedagogy, curriculum design, and program deivery.

Research activities, and research-only academic positions in engineering schools have grown over the past decade partly (even significantly) through subsidy from the fees for international *coursework* students. Such fees may contribute to research student scholarships (domestic and international), attraction and retention allowances for key research leaders and other academic staff, start-up funds, etc.

ACED's submission to the National Innovation Review proposed the need for full funding of research to reduce subsidies from teaching revenue. This includes the notion of full-cost funding of investigators' salaries and full-cost infrastructure support for competitive grants, and elimination of the requirement of universities to provide up-front cash for CRC bids. A second critcal area is the need for better incentives and rewards to attract and retain more of the best doctoral graduates in engineering schools. Some of this might take place through the development of joint-industry appointments. But the lack of higher degree research candidates in future-critical areas is a broader issue that applies in many science-based areas. The stipends available for research training are far too low in comparison with those available to graduates entering industry. The perceived low value (to industry) of a research degree and prospective uncertainties in academic careers of subsequent prospective careers in univerisites depress enrolment into research degrees. The outcomes of this Higher Education Review must assist to strongly promote the universites, and the notions that intellectual activity and high-end skills are absolutely vital to Australia's future.

Question 20: on research concentrations

The engineering review (ref 1, pp 43-46) discussed the growth of research through national centres of excellence, institutional centres and cooperative research centres. Concentration, even in geographically distributed centres, provides the critical mass needed for tackling many increasingly complex research questions, better utilisation of costly equipment, and richer environments for higher degree research students. While ACED would expect to see engineering research continue to "concentrate" we also urge

that such concentrations do not diminish the quality of the engineering education provided in their (parent) institutions.

Without full research funding (to underwrite the full replacement of staff from the supporting teaching area, and full-cost infrastructure associated with competitive grants and CRCs), the teaching loads on the "school" academics may become excessive. Further, too much of the teaching talent of academics seconded to such centres may may be lost to undergradate and postgraduate students. We contend that the best outcomes for research and teaching will result from a holistic and constructive integrated management approach by those responsible for both teaching and research.

Question 21: "teaching-only" universities

ACED does not support the concept of "teaching-only" engineering schools (or universites) on both philosophical and practical grounds. Professional engineering is about creating new futures using leading edge technologies and new materials, and challenging the boundaries of current practice. Engineering programs aimed at professional engineering qualifications require their students to understand advanced knowledge in their area of specialisation, and undertake open-ended projects. The sources of the ideas for these, and the equipment used to undertake them, often come from academic supervisors' research. The latter may be taken to include industry-based work on engineering processes, rather than work aimed at publication in engineering science journals. ACED contends that a "teaching-only" system that precluded academics from undertaking any research would greatly impoverish their students' education. A related objection to "teaching-only" engineering schools is that they would simply not attract academic staff of the calibre required to deliver quality programs to very able students. The ability to undertake independent research is what attracts and retains engineering academics who would otherwise move into industry where thay may well earn much higher salaries.

ACED recommends:

- **that consideration be given to full-cost funding for research supported by competitive grants;**
- **the urgent consideration of a major expansion of the numbers and financial support available to higher degree research candidates in critical emerging areas, to attract and retain the best doctoral graduates.**

REFERENCES

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