Engineers for the Future

addressing the supply and quality of Australian engineering graduates for the 21st century

Summary and Recommendations

Robin King

This report is an outcome of a project undertaken by the Australian Council of Engineering Deans with support from the Australian Learning and Teaching Council, Engineers Australia, the Australasian Association for Engineering Education, and the Australian Academy of Technological Sciences and Engineering.

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Engineers for the Future: summary and recommendations

This report contains a summary of findings and recommendations presented in the report *Engineers for the Future: addressing the supply and quality of Australian engineering graduates for the 21st century*. Both reports are outcomes of an original project undertaken by the Australian Council of Engineering Deans (ACED) and supporting partners, under the title *Addressing the Supply and Quality of Engineers for the New Century*.

Support for this project has been provided by The Australian Learning and Teaching Council, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this report do not necessarily reflect the views of the Australian Learning and Teaching Council. Ltd.

The original project report may be accessed at http://www.altc.edu.au/carrick/go/home/grants/pid/343

The project was administered by the University of Technology Sydney, with key personnel:

Project Leader:	Professor Archie Johnston, ACED Past President Dean of Engineering, University of Technology Sydney
Project Manager and Report Author:	Emeritus Professor Robin King, University of South Australia Adjunct Professor, University of Technology Sydney
Project Assistance:	Emeritus Professor Alan Bradley, Engineers Australia
Steering Committee Chair:	Emeritus Professor Mary O'Kane, FTSE

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Foreword

Over the last two decades at least, Australia's engineering education system, through its engineering schools, professional institutions and related academies and societies, has demonstrated an ability to reflect on its practice and performance and adapt to changes of technology and the changing expectations of society. Indeed, these stakeholders have endeavoured to anticipate future needs, and position the system to develop graduates who are well equipped to take leading positions in the profession and society at large.

The current project has built on the mid-1990s review of engineering education, published as *Changing the Culture*: *engineering education into the future*. The recommendations of that review led to comprehensive revision of the program accreditation processes and substantial curriculum innovation and reform. Despite these good outcomes, the anticipated increase in participation by women reached only a relatively low plateau around 2001. The demand for Australian engineers continues to exceed graduate supply. Engineering study has remained a distinct minority interest for most Australian school leavers. Increasing the size of the pool of qualified and motivated school leavers for engineering study present continuing challenges.

This report is an outcome of the consultative review of the national engineering education system undertaken during 2007 by the Australian Council of Engineering Deans with strong support from Engineers Australia, the Australasian Association for Engineering Education and the Academy of Technological Sciences and Engineering, and funding from the (then) Carrick Institute for Learning and Teaching in Higher Education Ltd. The research methodology and implementation were largely devised and carried out by Emeritus Professor Robin King.

The study examined the state of the engineering education system, with respect to its ability to meet future challenges. The study revealed a diverse and responsive system, many examples of good practice in engineering education that provide a sound platform for future development, and many highly able, articulate and ambitious students and graduates. The study also found system stresses: increasing student-staff ratios; difficulties in making academic appointments at all levels; lower incentives within the system for improving teaching than for developing research; inadequacies in the provision of laboratories; and variable connectivity with industry. The study found a stakeholder community believing strongly that a good engineering degree can be a passport to success in many of life's endeavours, seeking to ensure that its degrees are indeed 'good', and that they deserve to attract to a wider sector of the population. As part of the project, ACED developed a vision for the engineering education system.

The Steering Committee guided the review towards recommendations for future action that will ensure Australia continues to operate an engineering education system capable of meeting Australia's current and future needs and maintain parity with international best practice. Already, five months after completion of the study, actions are in place for several of the recommendations. In commending the report and its recommendations, I record my thanks to my colleagues on the Steering Committee and all who contributed to the review especially Robin King whose dedication to engineering education and wisdom in steering us to a new vision for engineering in Australia shine through this report.

Mary O'Kane
Chair, Steering Committee
October 2008

Summary of Recommendations

Recommendation 1: raise the public perception of engineering

Raise the public perception of engineering, including within primary and secondary schools, by increasing the visibility of the innovative and creative nature of engineering and the range of engineering occupations that contribute to Australia's prosperity, security, health and environment.

Recommendation 2: refine the definition statements for engineering occupations and graduate qualification standards

Develop, support and promote the concept, reality and importance of all members of the engineering team – Professional Engineers, Engineers Technologists and Engineering Officers – in the successful implementation of engineering work. Review the graduate competencies and reference standards for the qualifications for each level.

Recommendation 3: implement best-practice engineering education

Engineering schools must develop best-practice engineering education, promote student learning and deliver intended graduate outcomes. Curriculum will be based on sound pedagogy, embrace concepts of inclusivity and be adaptable to new technologies and inter-disciplinary areas.

Recommendation 4: improve resources for engineering education

Enhance staff and material resources to enable delivery of engineering education that is demonstrably aligned with Australia's needs and compliant with international standards.

Recommendation 5: engage with industry

Engineering educators and industry practitioners must engage more intensively to strengthen the authenticity of engineering students' education.

Recommendation 6: address shortages by increasing diversity in engineering workplaces supported by engineering education programs

Address shortages in the engineering workforce by attracting and retraining people from non-traditional backgrounds e.g. women, mature age engineers, engineers with overseas qualifications, engineers who have left the profession, and engineers wishing to articulate between qualification levels. Ensure the future needs of employers are matched by the number and types of programs on offer.

The full recommendations and proposed actions are provided later in this document.

Summary of Findings

Introduction and Context

Engineers conceptualise, create and maintain physical and information-based products, processes, systems and assets that satisfy human and economic needs, and have minimal environmental and negative human impacts. Engineers are thus critical to Australia's economy, security, health and environment. Engineering is increasingly complex and multidisciplinary, and is practised diversely, in business, government and educational enterprises. Engineering is a key component of the nation's innovation system.

Australia's higher education sector provides entry-level education to professional engineers, engineering technologists and engineering officers, as well as advanced level education and engineering research. The universities' engineering schools aim to provide education awards and pathways to satisfy students' aspirations and employers' needs, and work closely with employers and with program accreditation processes to ensure these needs are met to relevant international standards. Consequently, engineering education and accreditation have responded to changes in engineering practice brought about by new scientific and technological knowledge, and to changing economic and regulatory forces.

This document contains a summary of the findings and the full recommendations of a year-long consultative study undertaken by the Australian Council of Engineering Deans (ACED), supported by Engineers Australia, the Academy of Technological Sciences and Engineering (ATSE), and the Australasian Association for Engineering Education (AaeE), with project funding from the Carrick Institute for Learning and Teaching in Higher Education, now the Australian Learning and Teaching Council.

The study has examined the current state of the higher education component of the Australian engineering education system with respect to its ability to address future needs. It has been conducted at a time when the national demand for engineers exceeds graduate supply, with reported shortages of some 20,000 engineers in early 2008. The study used publicly available information, mostly from the Higher Education Statistics collections of the Department of Education, Employment, and Workplace Relations (DEEWR), submissions and consultations with stakeholders in engineering education, including students, recent graduates and employers.

The study has also considered the implementation of outcomes of the 1996 Review of Engineering, *Changing the Culture*. The principal outcomes from that review were:

- Engineers Australia, in collaboration with ACED, redesigned and implemented the program accreditation process to have greater emphasis on generic graduate attributes. After some 8 years of operation, the new processes are judged to be successful in focussing programs on outcomes, and supporting educational innovation.
- improvements in curriculum design and delivery in Australia's engineering schools, including project-based and problem-based learning, and increased emphasis on student teamwork and communications, and on issues of management and sustainability.

The *Changing the Culture* review also proposed increased participation of women and other under-represented groups, and aimed for the number of Australian first-degree engineering graduates to increase by more than 2-3% per annum. In fact, the total number of Australian first-degree engineering graduates has been around 5,500 over the decade to 2005. The data presented here show that the proportion of female graduates from all awards increased from 13.6% in 1996 to 17.1% in 2003, but has since declined. The present study also reports that the size of the pool of Australian school leavers qualified for engineering study is tending to

decrease. Attracting school leavers and mature people into engineering remain challenges to the universities and the profession as a whole.

The full report provides many examples of good practice in engineering education, and full references. The report addresses emerging issues and makes six recommendations with associated actions proposed as a 'roadmap' for future work by the stakeholders. For each of the recommendations, presented in full later in this document, there are identified leaders, stakeholders, milestones and measures, and a number of specific actions.

Australia's Engineering Schools: student and staff numbers

Education programs at the Professional Engineer and Engineering Technologist levels are currently provided by the engineering schools in 32 Australian public universities, and in none of the private institutions. There has been considerable growth in total student numbers at all award levels since 2000, particularly by international students, some of whom study outside Australia (see Table 1). Many of the Australian students study part-time, so the equivalent full-time student load is approximately 60% of the student numbers shown in Table 1.

Table 1 Total enrolments (students) in engineering awards, 1996 – 2006, with proportions of women and international students at each award level

award level	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
doctorate	2,319	2,321	2,371	2,449	2,531	3,245	3,374	3,699	3,985	4,110	4,199
% female	15.7	16.6	18.3	18.8	20.7	21.4	20.7	20.4	20.8	20.6	21.1
% international	23.6	22.3	21.3	20.5	19.3	21.4	22.3	23.3	24.7	27.0	30.1
research masters	1,313	1,261	1,181	1,124	1,044	1,157	1,212	1,184	1,287	1,253	1,214
% female	17.1	18.3	18.0	18.1	15.6	17.0	16.9	18.8	18.7	21.1	20.8
% international	19.4	18.5	18.4	18.1	18.6	20.3	21.5	23.7	28.0	32.0	35.3
coursework masters	2,314	2,316	2,200	2,246	2,414	3,799	4,706	6,584	7,102	7,178	6,656
% female	12.5	14.0	14.7	16.7	16.3	18.2	17.0	15.7	16.2	16.6	16.7
% international	24.3	26.9	29.5	36.3	43.8	53.3	56.3	65.8	67.7	68.4	65.3
other postgraduate	1,715	1,777	1,337	1,265	1,342	2,163	2,228	2,273	2,263	2,456	2,546
% female	14.5	15.8	17.0	16.1	18.1	17.4	18.1	16.4	17.4	16.8	18.5
% international	8.5	8.5	11.5	9.2	18.0	15.1	17.5	11.4	11.4	15.6	16.7
bachelor degree	40,085	41,468	42,063	42,766	42,791	46,891	48,202	49,402	49,441	48,851	49,676
% female	13.8	14.0	14.2	14.5	14.9	15.5	15.6	15.4	15.0	14.7	14.5
% international	10.3	11.3	11.9	13.0	14.0	17.2	19.7	22.2	23.5	24.0	24.3
associate degree*	942	245	195	653	593	741	862	806	827	963	1,238
% female	6.9	9.0	7.7	7.7	6.6	5.0	9.0	10.2	7.7	11.0	16.1
% international	2.8	0.0	6.7	2.0	3.0	4.3	11.5	12.0	14.1	19.6	22.7
other undergraduate	26	610	576	72	98	287	654	710	612	546	636
% female	7.7	6.4	7.1	37.5	29.6	13.2	9.5	11.0	7.2	15.4	17.9
% international	0.0	2.5	1.0	4.2	4.1	2.1	2.0	10.0	8.5	11.0	13.2
Total	48,714	49,998	49,923	50,575	50,813	58,283	61,238	64,658	65,517	65,357	66,165
% female	13.8	14.2	14.4	14.8	15.3	16.0	15.9	15.7	15.5	15.4	15.4
% international	11.6	12.5	13.1	14.3	15.7	19.5	22.3	26.1	27.8	28.8	28.5

* including university Diploma awards, pre 2004

Data: DEEWR via Engineers Australia

Most of the engineering schools offer 4-year programs that are accredited by Engineers Australia as entry-level qualifications for professional engineering. Many schools offer alternative study patterns for equivalent engineering qualifications, including 'dual', 'double' and combined" degrees and various '3 + 2' year models that lead to masters awards. This diversity provides a good platform of experience for future development.

Many of Australia's most able school leavers choose engineering and progress to high profile careers in engineering and other areas. Engineering students express strong aspirations to contribute to engineering solutions in sustainable infrastructure and manufacture, and to working at the leading edge of scientific and technological research and application. Others choose engineering for its pathway to management.

Table 2 Commencing enrolments (students) in engineering awards, 1996 – 2006, with proportions of women and international students at each award level

award level	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
doctorate	592	671	655	655	732	771	840	872	951	822	847
% female	20.3	18.3	22.0	19.7	23.9	22.7	21.7	19.8	21.1	19.8	23.3
% international	24.2	23.8	25.0	25.2	24.0	30.7	26.9	29.5	27.8	33.1	42.6
research masters	499	542	450	443	421	419	483	454	519	429	392
% female	13.4	14.8	14.2	14.9	11.2	12.4	15.3	16.7	15.0	14.0	11.7
% international	25. %	20.5	25.3	22.1	26.6	28.9	29.0	34.8	39.1	41.3	45.4
coursework masters	1,081	1,107	1,130	1,300	1,497	2,103	2,752	3,857	3,751	3,455	3,238
% female	14.0	14.4	14.6	16.5	14.6	17.5	16.8	14.9	16.3	17.0	16.6
% international	33.4	37.1	38.5	49.3	54.5	62.1	63.4	73.9	74.3	74.6	70.9
other postgraduate	1,114	1,127	828	815	875	1,299	1,222	1,243	1,157	1,363	1,322
% female	13. %	13.2	13.6	11.9	13.5	14.9	14.3	12.8	14.4	14.0	15.0
% international	10.7	10.4	14.6	11.2	20.9	17.0	21.0	11.9	14.0	21.6	24.4
bachelor degree	12,233	12,763	12,514	12,974	12,676	14,160	14,137	14,369	13,846	13,698	14,142
% female	13.9	14.0	14.4	14.9	15.5	15.5	15.1	14.9	14.4	14.1	14.5
% international	13.4	14.0	12.9	15.8	17.6	23.8	27.3	29.8	28.4	27.6	27.3
associate degree*	335	76	114	293	241	269	412	322	336	568	602
% female	8.1	5.3	5.3	8.9	6.2	5.6	13.3	6.5	3.3	15.3	18.8
% international	2.4	0.0	11.4	3.1	6.6	6.3	18.7	8.4	12.5	26.2	27.2
other undergraduate	25	246	261	70	90	242	583	662	565	481	553
% female	8.0	2.8	6.1	38.6	31.1	13.2	9.4	10.4	6.2	15.4	17.4
% international	8.0	1.6	0.4	4.3	4.4	1.2	4.8	7.1	6.4	17.9	23.9
total commencing	15,881	16,534	15,954	16,552	16,534	19,266	20,432	21,782	21,128	20,819	21,099
% female	13.9	14.0	14.4	15.1	15.5	15.7	15.4	14.7	14.6	14.8	15.3
% international	15.1	15.6	15.5	18.5	21.4	27.4	30.9	35.4	35.0	34.8	34.0

* including university Diploma awards, pre 2004 Data: DEEWR via Engineers Australia

Engineering attracts proportionally fewer Australian higher education students than many other countries. Commencing student numbers in all higher education engineering programs are shown in Table 2. On average, only 6% of commencing Australian enrolments start engineering programs. The proportions of school leavers qualified for engineering through study of intermediate and higher levels of secondary school certificate mathematics have

declined continuously in recent years. The majority of such qualified students, particularly women, select higher education study in fields other than engineering.

There are 12,000 ~ 13,000 graduates from all higher education engineering awards each year, of whom fewer than half are Australian graduates from bachelor degree programs (Table 3). There is relatively high attrition of Australian students from first-degree engineering programs: on aggregate, approximately 48% of the men and 40% of the women who commence study in bachelors engineering programs do not graduate from them.

The proportions of graduates in electronic and computer engineering, and mechanical and manufacturing engineering peaked around 2003-4. Civil engineering first-degree enrolments are now recovering rapidly their low point in the late 1990s. Newer fields, such as environmental engineering and biomedical engineering graduate quite small numbers. Mining and electrical engineering enrolments are now increasing due to strong support from those industry sectors.

Table 3 Graduations from engineering award programs, 1996 – 2005, showing the proportions of women, international students graduating at each award level.

award level	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
doctorate	413	471	438	436	474	420	480	528	570	637
% female	12.6	12.1	16.7	15.6	16.2	19.5	16.7	21.0	19.3	19.9
% international	29.5	30.1	25.8	26.6	25.1	23.1	20.6	20.5	26.1	29.0
research masters	237	261	230	195	189	206	185	194	220	208
% female	20.3	16.5	16.5	22.1	26.5	20.9	20.5	20.1	17.7	22.6
% international	24.9	23.0	28.7	26.2	24.3	29.1	22.2	23.7	33.2	36.1
coursework masters	831	949	972	1059	1052	1552	1695	2379	2587	2934
% female	10.6	13.9	13.1	13.2	17.7	19.7	18.5	16.3	17.0	17.2
% international	38.9	37.5	41.7	48.9	56.5	59.0	63.2	72.1	75.1	78.4
other postgraduate	630	698	651	556	513	517	484	556	528	558
% female	13.5	13.6	11.7	15.5	13.1	15.5	15.9	17.6	18.6	18.3
% international	13.5	22.8	19.7	6.8	17.3	20.9	31.0	26.1	22.5	34.9
4-year bachelors(1)	6,008	6,330	6,559	6,507	6,613	6,790	6,486	6,856	7,251	6,876
% female	14.2	14.9	14.8	14.9	15.1	17.3	17.8	18.0	17.6	17.2
% international	12.0	12.7	15.4	19.1	21.5	19.9	21.3	23.6	25.2	28.1
3 –year bachelors			included in above			929	983	972	949	1,200
% female						14.6	14.0	12.9	13.3	17.1
% international						33.4	37.4	39.1	41.6	38.9
associate degree(2)	206	76	74	154	120	184	222	191	182	190
% female	3.9	13.2	5.4	10.4	5.0	2.7	4.5	13.1	18.7	7.4
% international	5.8	1.3	10.8	5.8	6.7	9.2	16.2	18.3	31.9	25.8
other undergraduate	11	99	76	16	9	113	297	264	456	191
% female	0.0	5.1	1.3	6.3	0.0	3.5	4.7	6.4	0.7	5.2
% international	0.0	4.0	1.3	12.5	0.0	0.9	1.7	19.7	2.6	9.4
total graduates	8,336	8,884	9,000	8,923	8,970	10,711	10,832	11,940	12,743	12,794
% female	13.6	14.5	14.4	14.8	15.5	17.1	16.8	17.1	16.7	17.1
% international	15.8	17.2	19.2	22.2	25.4	26.7	29.1	34.3	35.9	40.8

(1) including equivalent awards

(2) including university-based Diploma awards, pre 2004

Data: DEEWR via Engineers Australia

Most of the engineering schools also offer postgraduate coursework degrees, from which approximately 2,500 international students graduated in 2005, making up more than 75% of the total graduates at masters level. Such 'stand-alone' masters degrees are not accredited by Engineers Australia, since they are primarily designed for graduates to gain post-graduate level specialist engineering knowledge or engineering management skills, rather than to gain the career entry-level professional qualification.

About half of the universities also offer 3-year undergraduate programs that qualify graduates as engineering technologists, with some 1,200 graduates in 2005. However, demand by school leavers for this qualification is low, and several engineering schools have ceased taking new enrolments into these programs. There are also a small number of 2-year Associate Degree programs in engineering, mostly developed in close association with specific industry sectors.

Table 4 Full-time equivalent (FTE) staffing employed in engineering schools, 1996 – 2006, by gender and academic role

staff groups	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
academics, male											
teaching-only	62	70	71	70	63	63	60	53	66	57	41
research -only	474	527	479	522	503	636	686	753	834	834	915
teaching & research*	1,687	1,637	1,485	1,498	1,399	1,480	1,477	1,488	1,464	1,520	1,478
sub-total, academic males	2,223	2,234	2,035	2,090	1,965	2,179	2,223	2,294	2,364	2,411	2,434
academics, female											
teaching-only	2	6	3	5	4	3	3	4	12	1	1
research -only	83	98	63	94	103	145	169	183	195	190	225
teaching & research	99	103	111	127	125	152	156	155	157	181	171
sub-total, academic females	184	207	177	226	232	300	328	342	364	372	397
total academics	2,407	2,441	2,212	2,316	2,197	2,479	2,551	2,636	2,728	2,783	2,831
% research-only	23.1	25.6	24.5	26.6	27.6	31.5	33.5	35.5	37.7	36.8	40.3
% female	7.6	8.5	8.0	9.8	10.6	12.1	12.9	13.0	13.3	13.4	14.0
support staff											
male	1,263	1,236	1,161	1,088	988	992	993	1,030	984	1,009	901
female	536	558	521	536	521	560	597	645	618	643	597
total support staff	1,799	1,794	1,682	1,624	1,509	1,552	1,590	1,675	1,602	1,652	1,498
% female	29.8	31.1	31.0	33.0	34.5	36.1	37.5	38.5	38.6	38.9	39.9

* the standard career academic role is designated 'teaching & research' data provided by DEEWR

There has been considerable growth in university engineering research over the decade, including through participation in national centres of excellence and cooperative research centres. Research in engineering schools attracts good staff, builds reputations, and contributes to the national innovation system. The sector-wide staffing numbers provided in Table 4 show the changing balance between research and teaching academic staffing, and reduction in support staffing over the decade.

The study has also identified substantial strengths in many of Australia's engineering schools in the areas of engineering education research, international education, outreach to secondary schools, and in addressing industry-specific skills shortages though new undergraduate and postgraduate programs, some of which are referred to in the following paragraphs.

Increasing Graduate Supply: new pathways and programs

The study identified four possible approaches to increase the supply of graduate engineers:

- increase the size of the pool of school leavers who are qualified and motivated to study university engineering programs;
- increase the overall success rates of students who embark on engineering programs through improvements in engineering curricula and pedagogy;
- improve the opportunities for women, mature-entrants and other under-represented groups, and overseas-qualified graduates to enter and re-enter engineering, through clearer educational pathways and on-going career support;
- offer alternative study pathways to qualifications that prepare graduates for commencing careers as professional engineers, engineering technologists and engineering officers.

The study also identified experience and capabilities in many of Australia's engineering schools that have the potential to meet graduate demand by increasing the flexibility of engineering study and thus adapting to a wider population of students as well as by reducing attrition.

Such capabilities and experience include:

- provision of accredited professional engineering qualifications in combination with other awards, including science, management, arts and law; and in a variety of study patterns including industry-based learning (co-op); and 'articulated' awards in which the accredited degree is a masters award;
- advanced study programs and opportunities for the most able engineering students to undertake greater depth of study, extended project work, and to develop leadership skills;
- foundation and bridging programs that enable students who have not met the normal pre-requisite study requirements, but have proven aptitude for engineering;
- many forms of practical engagement, including student-peer mentoring to assist secondary school students in mathematics and science, and projects and competitions that improve attainment in school science and mathematics and increase students' awareness and motivation for engineering studies;
- effective exploitation of new technologies and new approaches in engineering education, that can contribute to reducing attrition rates;
- good industry support for collaborative post-graduate program development in some areas of high level skills demand;
- exploitation of the many areas of internationally competitive research strength, in national research centres of excellence, including cooperative research centres, and in university-supported centres and institutes in areas of national importance, to raise the status of Australian engineering schools, as well as the supply of highly capable graduates.

Graduate Qualities and Outcomes: towards best practice engineering education

The study found employers to be generally satisfied with current engineering graduates. Typical graduates have strengths in using information technologies, and are generally better oral communicators and team-members than those of earlier generations. Many graduates are employed in global companies where their skills are demonstrated as the equal of those from

other nations that have stronger engineering traditions. Australian students perform well in international engineering design-based and entrepreneurially-focussed competitions, many of which form part of the formal curriculum.

Employers also raised concerns:

- of poor standards of report-writing (a criticism levelled at graduates of fields other than engineering), but that must be addressed;
- that graduates have less grasp of 'fundamentals' than those of earlier generations, and less ability to validate intuitively the results of computer based simulations or conceptual designs;
- that the system is producing too few graduates with adequate skills in construction and project management, and assessment of risk.

The engineering community as a whole considers that the current undergraduate engineering curriculum emphasis on broad generic outcomes as well as sound technical knowledge should make engineering a more highly desired study program than it currently is to Australian school leavers and mature people.

To further increase attractiveness and reduce attrition, engineering programs will require profound curriculum changes. These must take into account the attitudes and aspirations of contemporary students.

The full report outlines current directions in best-practice engineering curriculum design and implementation, with greater emphases on active learning (including problem and project-based learning) and more methodical coverage of the whole engineering life-cycle. Pedagogical and curriculum developments including the use of remote-access laboratories; project-centred curricula; and improved assessment methods, are also discussed.

Key and emerging themes for engineering education and subsequent professional practice need to be consolidated and embedded. These include:

- the engineering life-cycle of concept, design, implementation and production, operation and maintenance and retirement; with increasing emphasis on:
  - dealing with uncertainty and risk assessment;
  - systems thinking, and integrating ideas and technologies;
- managing complex engineering projects, including deploying resources (logistics, people and money) with maximum efficacy, in a range of time-varying and broad ranging contexts including political, cultural, social, legal, business, environmental, health, safety and other influences;
- mathematical modelling (of physical systems and information processes) and using such models in engineering tools, and noting the need to develop engineering students' mathematical abilities in the context of engineering examples;
- scientific knowledge of established and emerging areas at the interfaces between traditionally defined areas, and increasingly in areas that involve biological sciences, technology and systems.

The full report discusses the notion that future education programs for professional engineers may need to be designed more clearly and purposefully for practice in advanced engineering science and technology on one hand, or in systems integration and project management on the other. Future programs for engineering technologists may also need to have similar attributes but at the same time a differentiation of focus.

Staffing and Resources

The study found declining resources available to Australian engineering schools, particularly those funded from the revenue derived from Australian student enrolments. Such trends have direct impact on the quality of programs that can be delivered. In particular:

- the average ratio of full-time effective student load to full-time equivalent teaching staff has increased from about 14 in 1995 to about 21 in 2007. The latter figure is a third higher than internationally accepted norms for internationally comparable engineering schools;
- Australian engineering academics are under considerable pressure to favour research over teaching, and to undertake high administrative loads, making traditional academic careers less attractive options than industry or full-time research;
- there is inadequate provision of educational training, professional development, incentives and rewards for improving engineering teaching and undertaking engineering education research;
- the relatively small numbers of higher degree research students in engineering compromise the research capacity of the engineering schools, Australia's innovation potential, and the ability to replace of retiring academic staff;
- the general quality of engineering laboratories also gives considerable cause for concern: many have outdated and unreliable equipment, and declining numbers of technical staff to maintain them to safe standards.

On the other hand, it is widely recognised that there is considerable scope for developing improved systems for sharing curriculum materia, resources and development effort between engineering schools, thereby improving efficiencies and achieving higher level outcomes for a bigger population of graduates.

Industry Links

The importance of having effective and systematic industry input into engineering education is widely recognised by all stakeholders. The study has focussed on exploring mechanisms to improve the 'authenticity' of the students' learning experience by measures that:

- increase the extent and quality of students' industry experience and workplace-based learning in the curriculum;
- use site-visits and industry case-studies more effectively and increase industry-related laboratory and project work;
- increase the number of joint industry-academic appointments, and opportunities for academics to gain experience of contemporary industry practice.

In addition, members of industry and the profession have indicated willingness and support for improving the quality of engineering teaching laboratories, and ensuring that their investment in such facilities can be utilised as widely as possible.

The need for more systematic and unified engagement with industry including multi-institutional approaches is emphasised, as has been exemplified in a number of industry sectors.

There are also widespread concerns about the low levels of participation of Australian engineers in postgraduate coursework and research, in so far as this reflects on Australian industry's strengths and needs for innovation-led development.

The Visibility of the Engineering Profession

Despite modern society's dependence on it, the work of professional engineers in Australia is widely perceived to be invisible to the public at large. Members of the public are not routinely involved in engaging the services of professional engineers or engineering technologists, and engineering is not a formal subject in primary or most secondary school curricula.

This lack of visibility and limited understanding of the engineer as problem solver and creative designer of infrastructure, products and systems, are believed widely to contribute to the low demand for engineering study.

Australia appears to lack a national culture in which engineering research and innovation are seen as foundations that must underpin the economy and its development. Scientific 'breakthroughs' are celebrated almost daily in the media, yet engineering projects enjoy less profile or public acclaim.

The study finds a strong case for increasing the media visibility of the positive outcomes and value of engineering, and for promoting public knowledge of prominent and successful engineers and business leaders with engineering backgrounds.

Engineering schools, Engineers Australia and ATSE have worked intently over the years to increase the awareness of the roles of engineers and scope, importance and excitement of engineering, especially through active, outreach programs in secondary schools. The report and its recommendations strongly endorse these activities, and suggest new areas for action.

Engineering Occupations and Qualification Standards

Engineering work is highly diverse and is often conducted by multi-level teams of professional engineers, engineering technologists and engineering officers (also known as associates and technicians). The Australian engineering education system has the responsibility to deliver programs leading to accredited awards at each of these levels, although the main focus of the engineering schools is on awards at the professional engineering level.

In their professional practice, graduate engineers tend to develop their careers around either specific technical specialisation or engineering project management and systems integration. Engineering leaders may emerge from either route. The study suggests that the engineering education system might benefit from clearer differentiation of award programs.

The Australian engineering program accreditation process operated by Engineers Australia has good standing amongst the signatories to the international Washington and Sydney Accords. Signatories to these accords recognise substantial equivalence of award qualifications for entry to practice at either the professional engineers or engineering technologist level, respectively. (Australia is not yet a signatory to the Dublin Accord for programs at the level of engineering officer.) Australia set its current accreditation criteria for the assessment of education programs at these occupational levels in the late 1990's. The development of Australian National Generic Competency Standards, defining the skills, capabilities knowledge, attributes and values expected for entry to professional practice at each of these levels was completed in 2004.

New international guidelines and range statements for each qualification level have recently been adopted by the signatories to the three educational accords. Several Washington Accord signatory jurisdictions are working towards longer study durations for entry to professional engineering practice. Like Australia, some of the other signatory jurisdictions (but not all) have reported low demand for engineering technologists programs, despite apparent alignments between the targeted competencies for this level and the requirements of industry for many engineering many positions. The study suggests undertaking further work on the nature (and diversity) of engineering occupations in Australian engineering practice to frame future standards for engineering award qualifications that will better meet Australian needs and the evolving international standards well beyond 2015.

Recommendations

The recommendations are intended to be a 'roadmap' for the next decade of development of Australia's engineering education system.

ACED will lead an implementation team as an activity of the Tripartite Agreement between ACED, Engineers Australia and ATSE. This team will champion and provide strategic leadership of the implementation of the recommendations, chart their progress, and report annually to their parent bodies.

Each of the recommendations has an identified responsible organisation with prime responsibility for obtaining funding, together with the other stakeholder organisations that may contribute to future actions. The measures and milestones may be used over time to track the progress of the implementation of the proposed actions.

Recommendation 1: raise the public perception of engineering

Raise the public perception of engineering, including within primary and secondary schools, by increasing the visibility of the innovative and creative nature of engineering and the range of engineering occupations that contribute to Australia's prosperity, security, health and environment.

Responsible Organizations: Engineers Australia, working with ATSE and ACED as an activity of the Tripartite Agreement, and with strong industry input.

Other Stakeholder Organizations: APESMA, ACEA, AAEE, BHERT, BCA, TAFE/VET; engineering businesses; government departments who own and operate engineering infrastructure; and the school education sector.

Measures and Milestones: (to be monitored under the Tripartite Agreement): for each of the following, the primary action leader is to set timelines and target figures and provide periodic reports on the process and achieved outcomes. The frequency and content of such reports are to be determined in consultation with the other responsible organizations and stakeholders.

(a) Promotion of engineering:

- increasing depth and accuracy of public perceptions of engineering and engineering occupations as measured in market surveys of general public and school students
- increasing positive media coverage of Australia's engineering enterprises and prominent engineers
- increased coordination of schools outreach activities in engineering

(b) Recruitment of students

- increasing proportion of the most able school students choosing engineering for tertiary study
- increasing numbers of mature entrants into engineering education, including re-entry pathways
- increasing engineering content in school education, including in mathematics and science
- increasing engineering content available in teacher education programs

Proposed Actions:

The proposed activities will be undertaken as collaborative partnerships, and integrated to build cohesively and substantially on the many activities already being undertaken, within minimum duplication of effort to maximise the outcomes of the resources available.

i) Convene high-level stakeholder forums to achieve engagement with this recommendation area, refine 'the message', and commission market research on the public perceptions of engineering and the work of engineers at each of the established occupational levels. (An underlying objective of future actions would be that membership of the professional engineering body would be perceived as equivalent to that of the Australian Medical Association for medical practitioners.)

Action leader: Engineers Australia

ii) Commission research to model the economic contributions and the risks of further decline of engineering education (at all levels) to Australia, and argue with government for differential funding model to restore staffing and laboratories to internationally competitive levels.

Action leader: ACED

iii) Engage the media at a high-level, to improve the accuracy of reporting on engineering, including wider exposure of national leaders in engineering or with engineering education, such as those identified in Engineers' Australia's '100 Most Influential Engineers', 'Women Engineers' and 'Young Engineers'.

Action leader: Engineers Australia

iv) Promote engineering education in universities more strongly by emphasising its contributions to society, outcome attributes and career and lifestyle opportunities, using case studies as well as some of the above initiatives, and stressing the human dimensions and the career pathways of highly successful young engineers and alumni. Emphasise the generic and enabling characteristics of engineering education.

Action leader: ACED and ACED members

v) Form consortia of engineering schools, industry and the school education sector to develop contemporary engineering examples to support school-level mathematics, science and technology subjects. Develop short courses on engineering for school educators in mathematics, science and technology, and also for school careers advisors.

Action leader: ACED

vi) Commission a nationwide study of school curricula to ensure that all states and territories have contemporary engineering subjects at senior levels to underpin increases in numbers of school students taking engineering at tertiary level. These subjects should stress creative design, systems and technological aspects of engineering and its broad context, and be preferred subjects for university admission to engineering.

Action leader: ACED

vii) Engineers in universities, industry and the profession must take a stronger lead in initiating and developing partnerships and outreach to the school education sector. This could be supported by a national repository of information about schools' science and engineering engagement and outreach schemes, to assist all stakeholders to increase the impact of their work and reduce duplication of effort.

Action leader: Engineers Australia with ACED

viii) Develop partnerships between engineering and education faculties at selected universities to facilitate the inclusion of engineering content in undergraduate and post-graduate teacher education programs and also to enable cross faculty teaching input to both engineering and teacher education at university level.

Action leader: self-selected ACED members

Recommendation 2: refine the definition statements for engineering occupations and graduate qualification standards

Develop, support and promote the concept, reality and importance of all members of the engineering team – Professional Engineers, Engineers Technologists and Engineering Officers – in the successful implementation of engineering work. Review the graduate competencies and reference standards for the qualifications for each level.

Responsible Organizations: Engineers Australia and ACED

Other Stakeholder Organizations: TAFE/VET, ATSE, AaeE

Measures and Milestones: Engineers Australia, as the primary organization responsible for implementing this recommendation, should set timelines for the development and review of the following. The timelines should include short- and long-term targets, including those to be addressed during the preparation of grant proposals:

(a) Standards and qualifications:

- revised graduate outcome standards and competency statements that meet current and future industry needs
- revised education program and qualification frameworks that meet required standards and can increase student demand for study at all qualification levels

(b) International standing

- increasing Australia's international position as a provider of high quality engineering education, and maintaining Australia's strong position within the International Engineering Alliance (Washington, Sydney and Dublin Accords)

(c) Student enrolments and throughput:

- ensuring sustainability of supply of high quality entrants into all levels of the engineering workforce that meet occupational needs
- increasing the overall throughput of students and graduates through the education system by providing clear and effective education programs with articulation pathways and professional development support

Proposed Actions:

i) Commission research on current and emerging occupational needs to support a review of Stage 1 competency standards and graduate outcomes for each of three internationally recognised occupational levels of the engineering team. Clarify the education and workplace expertise that is needed to progress between qualification levels.

Action leader: Engineers Australia and ACED

ii) Review the Australian qualifications, graduate competencies, reference standards, and registration requirements for the three engineering occupational levels and promote these within industry, the community and educational institutions the concept, reality and importance of each of these occupational levels underpinning the Australian engineering workforce.

Action leader: Engineers Australia and ACED

iii) Revise the current accreditation standards for education programs leading to the attainment of Stage 1 competencies for each of the three occupational categories defined for the engineering team, and address specifically issues of innovation and complexity in professional engineering. Ensure that these proposals include recognition (in a suitable manner) of stand-alone masters degrees in engineering, engineering science, and engineering practice.

Action leaders: Engineers Australia and AaeE

iv) Argue for enhanced government support for rapid development of programs and curricula to meet the new standards at each level, taking into account the range of school-leaver knowledge and skills in mathematics, science and English.

Action leaders: Engineers Australia and ATSE

v) Commission a study of the educational, personal and aspirational attributes of students commencing engineering awards at all levels, including masters. The study will include a specific focus on students in double/dual/combined degrees in engineering and their initial (5 year) careers as graduates.

Action leader: ACED

vi) Argue for enhanced government support for rapid development and deployment of postgraduate engineering conversion courses programs and curricula to address the shortage of professional engineers.

Action leaders: ACED, Engineers Australia and ATSE

Recommendation 3: implement best-practice engineering education

Engineering schools must develop best-practice engineering education, promote student learning and deliver intended graduate outcomes. Curriculum will be based on sound pedagogy, embrace concepts of inclusivity and be adaptable to new technologies and inter-disciplinary areas.

Responsible Organizations: ACED and AaeE

Measures and Milestones: the leaders of this recommendation should collect further data about the current status of education practice, as a baseline for gauging progress towards achieving the set milestones. They should set criteria for assessing progress, and devise processes for reporting and monitoring on outcomes that include expectations of:

- increasing employer satisfaction with engineering graduates, as measured by suitable sample surveys
- increasing graduate satisfaction with educational experiences and transitions to employment, as measured by GCEQ and suitable survey instruments
- systematic and holistic educational design practices with learning experiences and assessment strategies that focus on delivery of designated graduate outcomes
- increasing dissemination and sharing of development effort, best-practice course design, packaged learning resources and other courseware across engineering schools
- quality systems which rigorously close the loop on delivery of graduate outcomes
- increasing recognition of pedagogically sound, innovative and inclusive curricula
- increasing recognition and empowerment of engineering educators within universities
- increasing attractiveness of Australian engineering schools for international partnerships and student and staff exchanges
- increasing attractiveness of engineering to talented students and women

Proposed Actions:

This area will form the core of ACED's future proposals for funding from the Australian Learning and Teaching Council, through program and project proposals. ACED has the expectation that its members should endorse curriculum innovation undertaken locally and in consortia of similarly minded institutions, in program discipline areas, and thematic areas, building on examples of best known work. Over time, a more common set of approaches, with local differentiation, may be the most desired outcomes. ACED will need to establish processes

and metrics to actively support and monitor activities and outcomes. Some of the issues listed below will have different expression and implementation for each of the three levels of engineering award. Projects are envisaged that:

- disseminate pedagogically-sound and inclusive excellent educational design and practice developed nationally and internationally in engineering schools in recent years
- promote and implement systematic and holistic educational design and review approaches that track aggregated delivery of designated graduate outcomes through individual learning experiences and assessment processes
- examine the development and deployment of a professional engineering curriculum to be operated by consortia of engineering schools, based on a systems oriented common two-year core, followed by sub-discipline specialisation at the partner schools
- define and implement inclusive curriculum for engineering: reducing male stereotypes within the curriculum, and revitalising the best of the *Women in Engineering* programs (also Recommendation 6)
- develop understanding of the diversity of learning styles of commencing students, and the student work-life balance, and their impact on engineering curriculum (also Recommendation 2). This work has commenced through the Carrick Associate Fellowship's work 'Bridging the gap: matching students and staff through discipline-based self-evaluation and co-creation of more appropriate pedagogies in Engineering', to address aspects of students' learning styles and staff teaching styles.
- define curricula more strongly around engineering problem solving, engineering application and practice, and develop the themes of design, model-and network-centric engineering, the engineering life-cycle, complex systems, project management, global workflow, and multidisciplinarity
- develop stronger collaborations with mathematics and science departments to support improvements in the engineering education, and to contribute to the common interests of science, technology, engineering and mathematics (STEM) education
- implement engineering application activities that address contemporary issues and human dimensions, such as sustainability, environmental impact, risk, and social, business, legal, and economic factors
- internationalise engineering curricula and learning experiences
- reduce attrition rates from critical courses (without compromising outcome standards), using contemporary education theory, such as 'threshold' learning
- improve assessment practices, including peer-and self-assessment, and that minimise cheating, copying and plagiarism
- improve collaborative work and problem based learning, for example through the adoption of the CDIO framework, and introducing multi-disciplinary group projects at senior levels
- increase the authenticity of laboratory work and integrating more industry on-site experiences into courses
- improve the quality and intensity of industry-based learning
- define and implement appropriate business and management studies in engineering education
- commission evaluative surveys on relevant matters
- learn from other professional disciplines, such as architecture, law and medicine
- support associated staff development (also Recommendation 4)

Recommendation 4: improve resources for engineering education

Enhance staff and material resources to enable delivery of engineering education that is demonstrably aligned with Australia's needs and compliant with international standards.

Responsible Organizations: ACED

Other Stakeholder Organizations: AaeE, universities, Engineers Australia, ATSE, BCA, governments (Commonwealth & State – MCEETYA), business leaders

Measures and Milestones: in the following, the organization with primary responsibility should provide target figures and timelines. Periodic reporting should also be provided during grant proposal development. There is some overlap with the metrics proposed in Recommendation 3.

- increasing take-up of academic positions by candidates with substantial and relevant industry experience
- increased number of engineering academics with formal educational qualifications
- adopting strategies aimed at increasing recruitment of women engineers in engineering schools, particularly at and to senior levels (also in Recommendation 6)
- increased networking and sharing of best-practice learning design, courseware, laboratory activity and specialist resources, and other learning resources
- increased networking of acknowledged expertise in engineering education
- increased take-up of industry-based study leave opportunities
- increasing funding per enrolled engineering student
- increased sharing of resources between research and teaching
- increased utilisation of technological tools for enhanced access, support and enrichment of learning, and to facilitate a more unified educational design effort
- increasing take-up of engineering research degree candidature by Australian graduates
- increased cooperation between all education sectors and industry, and greater cooperation between undergraduate and masters students

Proposed Actions:

i) Facilitate discipline-wide approaches for more effective and systematic sharing of educational design, common courseware, learning resources and laboratory facilities for both underpinning foundation studies as well as high level specialist courses. Implementations should also build on the ACEN network project and ALTC/Carrick Exchange.

Action leader: ACED

ii) Develop and promote to government and industry the concept of a national strategy and endowment fund for laboratory equipment acquisition, operation and utilisation to ensure engineering education has access to best-practice engineering laboratories and learning spaces.

Action leader: Engineers Australia with the Tripartite Agreement

iii) Initiate discipline-wide discussions on frameworks for more effective and systematic sharing of best-practice support systems and staff deployment to maximise educational outcomes, for managing increased levels of student interaction and reporting, taking advantage of national funding schemes, such as CASR.

Action leader: ACED

iv) Promote to government and industry the need for specific additional funding and incentive support for higher degree research students in engineering, to nurture their progress, as professionals, some towards prospective academic careers.

Action leader: ACED with the Tripartite Agreement

v) Develop system-wide recruitment strategies and incentives to increase the supply of engineering academics, and particularly to support women to progress to senior positions.

Action leader: ACED

vi) Conduct workshops and forums for disseminating good engineering education practice in around emerging critical topics. (For example, take the annual AaeE national awards to a higher level, by having winners lead events.)

Action leaders: AaeE

vii) Investigate the merits of discipline-wide support for a national centre for engineering education that could become a leading provider of higher degree research in engineering education (including by distance delivery), and related coursework awards and professional development. Any such centre would be expected to link with the proposed Carrick DBI network covering science, engineering, mathematics, and IT.

Action leader: ACED

viii) Support (more strongly) academic staff to spend study-leave and other professional time in deep engagement with industry practice and have these outcomes accounted within university promotion processes where they are underpin improving curriculum in respect of improving students' engagement with engineering practice (also Recommendation 5).

Action leader: ACED

Recommendation 5: engage with industry

Engineering educators and industry practitioners must engage more intensively to strengthen the authenticity of engineering students' education.

Responsible Organizations: Engineers Australia, with ACED endorsement and monitoring of local, often industry-led initiatives

Other Stakeholder Organizations: Engineers Australia and ACED with industry and business partners, including BCA and BHERT

Measures and Milestones: in the following, the organization with primary responsibility should provide target figures and timelines. Process and outcomes should be identified and frequency and content of reporting on progress should be set.

- more effective and increasing input from industry practitioners to engineering schools in the processes of setting, reviewing and tracking attainment of graduate outcomes
- increasing quantum and quality of formal industry experience within engineering programs
- increasing evidence of exposure to professional engineering practice as an integral and substantive component of systematic educational design
- increasing number of joint university-industry appointments
- increasing number and value of industry-sponsored laboratories
- increasing number of industry-sponsored programs and short courses
- increasing academic staff experience of current industry practice
- increasing industry-supported scholarships for undergraduates and postgraduates

- increasing involvement of industry practitioners in teaching delivery

Proposed Actions – to be led by specialist industry groups and engineering deans and engineering program leaders in each university

i) Develop stronger and multi-institution industry advisory networks with sufficient stature to facilitate investment and commitment to educational improvements across the sector. The network could also be a lobbying force for increasing the profile and stature of engineering education as well as improving access to educational resources. Learn from other discipline areas, such as medicine and law where close cooperation between academics and industry is almost taken for granted.

ii) Set standards of industry engagement that are compatible with program vision and focus as well as a holistic educational design process (including engineering research). Ensure that standards embrace industry-based work-experience programs and other methods of exposure to professional practice that underpin an integrated and holistic educational design process that assures delivery of designated graduate outcomes.

iii) Build a more systematic and unified approach to industry engagement across the sector, with partnerships that are built on the principle of mutual benefit.

iv) Develop models and strategies for industry-sponsored scholarship schemes that will facilitate demand for places in engineering education, satisfy short and medium term skills needs and contribute to the delivery of quality graduate outcomes at each of the occupational levels.

v) Encourage and support academic staff to undertake collaborative research on engineering practice, with full recognition of outcomes that improve students' engagement practice. Best practice outcomes should also be reported in engineering education literature and forums.

vi) Encourage more university-industry joint academic appointments (at all academic levels), with adequate support by each partner to ensure maximum mutual benefits into engineering practice curriculum, as well as research and innovation.

vii) Increase the authenticity of students' educational experience with, for example, sponsored individual and group project work, joint laboratory development, programmed site-visits and high quality guest lectures on matters of contemporary engineering practice, industry led case studies and direct student engagement with practicing professionals, some under the auspices of funded 'industry fellowship' schemes.

viii) Increase the number and value of scholarships available to undergraduate and postgraduate students.

ix) Develop specialist engineering postgraduate programs and courses tailored to the needs of specific industry sectors (power, roads, transport, aviation, microelectronics, defence, water, etc.)

Recommendation 6: address shortages by increasing diversity in engineering workplaces supported by engineering education programs

Address shortages in the engineering workforce by attracting and retraining people from non-traditional backgrounds e.g. women, mature age engineers, engineers with overseas qualifications, engineers who have left the profession, and engineers wishing to articulate between qualification levels. Ensure the future needs of employers are matched by the number and types of programs on offer.

Responsible Organizations: ACED

Other Stakeholder Organizations: AaeE, Engineers Australia, ATSE, and industry and business partners

Measures and Milestones: increasing proportion and number of women undertaking engineering education, for all occupational categories

- increase opportunities for women engineers to maintain and upgrade their education
- increase in number of women engineering academics
- development of appropriate bridging courses
- increase number of overseas qualified engineers in the workforce

Proposed Actions:

In the following, the organization with primary responsibility should provide target figures and timelines. Process and outcomes should be identified and frequency and content of reporting on progress should be set.

i) Work with the Office for Women (and related agencies in the States) and Engineers Australia's National Committee for Women in Engineering to identify the major barriers to higher participation of women in engineering education, and reinstate and reinvigorate Women in Engineering programs within engineering schools.

Action leader: ACED

ii) In collaboration with employers, research the needs for educational support for women seeking to re-enter engineering practice after child-rearing, or seeking to maintain currency while in part-time employment.

Action leader: ACED

iii) Develop, with government, incentives to encourage women engineers to develop careers in engineering education.

Action leader: ACED

iv) Develop, with government and industry, incentives, including suitable bridging programs, support and opportunities to encourage engineers and others with motivation from non-traditional educational backgrounds (overseas qualifications, science degrees, VET, lack of pre-requisites) to enter and re-enter the profession, on fast-track accredited educational pathways.

Action leader: ACED and Engineers Australia

The Review Project and Ongoing Work

These findings, recommendations and vision were developed as outcomes of a year-long study, funded as a discipline-based initiative of the (then) Carrick Institute for Learning and Teaching in Higher Education, entitled 'Addressing the Supply and Quality of Engineering Graduates for the New Century'. The funding proposal was initiated by ACED in November 2006 and supported by Engineers Australia, ATSE and AaeE. The project itself was administered by the University of Technology Sydney, and guided by a Steering Committee of the stakeholders (see below).

The project proposal stated the aim of the engineering education system: "*To ensure that the engineering education sector across Australia's universities produces in a sustainable manner, a diverse supply of graduates with the appropriate attributes for professional practice and international relevance in the rapidly changing, competitive context of engineering in the 21st Century*".

The object of the study was, therefore, to explore the issues underpinning this broad aim, including: an evaluation of impact of the 1996 *Changing the Culture* review; impacts of the declining high school preparation in the enabling sciences and mathematics; international and mobility issues; gender balance; graduate outcomes; the value of engineering education as an enabler to different career options; industry-university partnerships; staffing and other resources; student attitudes and culture; and engineering and education research linkages.

The study focussed on Australia's higher education provision of education programs at bachelor, postgraduate and associate degree levels for Australia's engineering workforce. (The study did not include the VET sector's provision of engineering awards.) The consultative methodology received the views of approximately 1000 people, mostly in groups of employers, professional engineers, and academic staff, students and recent graduates of the 32 engineering schools in the university sector. Quantitative data were obtained principally from nationally validated sources. The full report contains examples of best-practice in many aspects of engineering education and much more detailed analysis of the main issues facing the system.

Under its funding schemes, the Australian Learning and Teaching Council is now funding a number of project proposals to act on a number of the curriculum and engineering qualifications issues identified in the recommendations. ALTC has committed more than $600,000 to projects and programs in engineering for over the next two years. The engineering schools, Engineers Australia and the Academy of Technological Sciences and Engineering are committed to the objectives of the review project, as well as their ongoing activities that intersect with its recommendations.

Project Stakeholders and Contributors

The **Australian Council of Engineering Deans** (ACED) was responsible for the conception, oversight and delivery of the study.

Engineers Australia contributed effort to the study, providing access to boards, committees and the general membership by publishing the requests for submissions.

The **Australasian Association for Engineering Education (AaeE)** has potential membership of all university academics involved in engineering education. In collaboration with Engineers Australia, AaeE hosted an industry-university workshop at its 2007 conference to focus on the key questions of the study.

The **Academy of Technological Sciences and Engineering (ATSE)** has provided guidance and publicity to the study.

The Australian Council of Engineering Deans

ACED is an unincorporated association of the 32 Australian universities currently providing accredited or provisionally accredited engineering degree programs.

The Australian National University	Monash University	University of Queensland
Central Queensland University	Murdoch University	University of Sydney
Charles Darwin University	RMIT University	University of South Australia
Curtin University of Technology	Queensland University of Technology	University of Southern Queensland
Deakin University	Swinburne University of Technology	University of Tasmania (now incorporating the Australian Maritime College)
Edith Cowan University	University of Adelaide	University of Technology Sydney
Flinders University	University of Ballarat	University of Western Australia
Griffith University	University of Melbourne	University of Western Sydney
James Cook University	University of Newcastle	Victoria University
Latrobe University	University of New South Wales	Wollongong University
Macquarie University	Australian Defence Force Academy (UNSW @ ADFA)	

A Vision for Australian Engineering Education

The Australian engineering education system provides diverse, high quality, internationally respected, industry focussed, professionally accredited education programs. These are delivered in well resourced, internationally benchmarked facilities by internationally regarded specialists in engineering and engineering education. The engineering programs have a strong emphasis on engineering practice, engineering design, creative problem solving and innovation. The system aims to support society at large towards enhancing the quality of life and securing a better future for all.

The education programs offer a wide range of pathways and choices to attract school leavers and mature entrants from diverse backgrounds. They inspire and prepare students to become creative, inventive and responsible professionals as well as life-long learners. Graduates will make positive contributions to their profession. Many will work towards solving significant challenges, such as global sustainability, water and energy supply. The education system provides a platform for launching graduates into influential leadership roles in engineering and other fields.

Australian engineering education is responsive and adaptive to technological, professional and societal needs. Operated across a wide range of universities and other educational institutions, the system strongly encourages collaboration between educational providers to maintain the highest possible standards and efficacy of delivery. Engineering academics and their work are highly regarded by students, graduates, employers, the engineering profession, and within their institutions.

The Australian engineering education system is recognised internationally as a global leader in engineering education through its well-researched and focussed contributions to educational developments and to the development of international accreditation standards. The system undertakes periodic review processes to evaluate its performance and recalibrate its objectives.