Australian Council of Engineering Deans

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SUBMISSION TO THE HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON INDUSTRY, SCIENCE AND INNOVATION

INQUIRY INTO RESEARCH TRAINING AND RESEARCH WORKFORCE ISSUES IN AUSTRALIAN UNIVERSITIES

from the

Australian Council of Engineering Deans

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SUMMARY

The Australian Council of Engineering Deans comprises the leaders of Australia's university-based engineering faculties and schools that are responsible for engineering education and research training.

In 2006, these schools had about 5,400 enrolled research students and nearly 3,000 full-time equivalent academic staff, of which more than 1,100 are designated 'research-only', and about 1,600 are designated as in 'teaching & research' positions.

Higher degree research (HDR) candidates provide much of the research output (common estimates are around 70%) of Australian engineering schools.

Of the 5,400 enrolled higher degree research candidates in engineering in 2006, about 30% were international students. The number of Australians commencing higher degree research candidature has declined since 2004. In 2006 the proportion of commencing international students was 42%.

ACED emphasises:

Research training programs in engineering are critical to the nation's future. Research trained engineers, including many working outside the universities, are likely to be leaders in developing creative and innovative solutions to many emerging challenges, and contribute to Australia's economy, environment, security and health.

The current enrolment trends (see above), and the strong international demand for high quality research students pose considerable risks to engineering research in Australian universities and to Australia's capacity for research-led enterprises.

ACED recommends:

That the Commonwealth government investigates and quantifies the return on investment (public and personal) in research training in engineering, and takes action to avert the risk of declining research training numbers in engineering, particularly by Australian graduates;

That the Commonwealth government raises significantly the number and value of tuition scholarships and stipends for engineering research for Australian and international graduates. An additional feature of a revised scheme could be to match more closely the number and distribution of fully funded research training places and stipends to Commonwealth project and program funded schemes.

In order to increase the quality and range of outcomes from research training, consideration be given to fully funding research places to include appropriate graduate coursework options to enhance the existing PhD programs and improve the capacity of PhD graduates to contribute to innovative research and business productivity.

That to strengthen university-based engineering research, measures are taken to increase the incentives and rewards for engineering research graduates and staff to remain in university positions, improve the opportunities for research-only staff to develop their careers, and to increase the number of joint university-industry appointments.

That measures are instituted to attract high quality international research students and staff, through scholarships, fellowships, industry-linked exchange programs, and enhanced migration status.

That measures are taken to increase the enrolment and retention of women in research degrees, and as research and academic staff.

INTRODUCTION

The Australian Council of Engineering Deans provides "*a forum for leaders of engineering education to discuss matters of mutual concern and national importance,… and to promote research and research training in engineering*"[1]. ACED comprises the leaders of the nation's 32 university "engineering schools", the entities responsible for the provision of engineering education and research training. Most of the academic staff (numbering about 2,850 in 2006) in these schools are active members of Australia's research workforce.

Our opening point is that engineering expertise is critical to Australia's future economy, environment, security and health, and fundamentally underpins the nation's innovation capability. Engineering is intrinsically connected to science, research, and business. The recent review[2] of engineering education in UK stressed the "*absolute importance of innovative and creative engineering*" … and the "*leadership roles of engineers*", … "*to the health and vitality*" of that nation. In his book on the history of engineering[3] the American physicist Sunny Auyang, wrote:

> *"Modern engineering … amplifies traditional ingenuity by the power of scientific reasoning and knowledge. … It acts at the vortex, merging research and development … and industry and business"*

Professional engineering is thus the creative and innovative activity that ultimately turns ideas into robust and reliable physical and information products and systems that have economic, social and environmental benefits. Each successive generation of engineers seeks to improve, essentially by successful innovation, on the outcomes achieved by their predecessors. While all engineering involves doing new things and keeping up to date with new technologies and methodologies of practice, research-trained engineers are likely to be the leaders of much innovation.

Many of the world's most successful industry and business leaders have research doctorates in engineering, and many industry sectors, such as microelectronics and information technology[4], have emerged from communities of doctoral graduates in engineering and related sciences. The clear inference is that the expertise gained in rigorous research training in engineering is a vital component of industrialised nations' innovation systems. Success in meeting economic and environmental goals and challenges is likely to have a strong positive correlation with higher numbers of engineering and science doctorates and strong supporting industry and capital raising processes.

Many of the examples and concerns expressed in this submission are drawn from the recently completed consultative review of engineering education[5] undertaken by the Australian Council of Engineering Deans (ACED) in partnership with Engineers Australia, ATSE, and the Australasian Association for Engineering Education, and funded by the (then) Carrick Institute for Learning and Teaching in Higher Education.

THE CONTRIBUTION OF RESEARCH TRAINING PROGRAMS TO AUSTRALIA'S COMPETITIVENESS IN THE AREAS OF SCIENCE, RESEARCH AND INNOVATION

The formal award programs of research training that Australia's engineering schools provide are absolutely vital to Australia's research and innovation effort. Higher degree research (HDR) candidates provide much of the research output (common estimates are around 70%) of Australian engineering schools. Their work contributes to the development of the body of knowledge on which further research and innovation are built, and a high proportion of research publications include research candidates amongst their authorship. In addition, research graduates gain broad research and professional skills that may be subsequently applied in new fields of research and innovation. Employment opportunities in

Australia for engineering research degree graduates may, however, be somewhat limited in number and scope outside the academic and government research organisations (CSIRO, DSTO and ANSTO).

While there are Australian examples (such as Cochlear Ltd, Bishop Technology Group Ltd.) of highly innovative and successful companies driven by engineering graduates of the highest order, the engineering education review (ref 5, p 45) also reported an engineering industry view that much university-led engineering research was "blue sky" and not directly relevant to industry need. This attitude may be linked to the lower level of business investment in research than in otherwise comparable OECD nations. The recent review (ref 5, pp 89 – 92) commented that the low visibility of research-led engineering industry in Australia is partly a cultural problem. ACED and the partner organisations to the review seek, through the recommendations in the review, to improve the visibility and public understanding of engineering, and the value of engineering research.

Higher degree research enrolments in engineering make up approximately 11% of the total higher degree research numbers, whereas engineering makes up only about 6.7% of all university enrolments, on 2006 data. Thus engineering is a more research intensive area of study than others.

Tables 1 – 3 at the end of this document provide Australian and international HDR total enrolments, commencements and graduations in engineering over the past decade. These data show:

- nearly 50% increase in total HDR enrolments over 1996 – 2006;
- an increasing proportion of HDR enrolments are international, making up more than 40% of all HDR commencements in 2006;
- a decline in the number of commencing research enrolments into both research masters and doctorates in engineering by Australian candidates since about 2002;
- a distinct shift in commencing enrolments from research masters, particularly for Australian students. This may be interpreted partly by assuming that more research students are enrolling directly into doctoral programs. Several universities require initial research enrolments into a masters program with subsequent admission into doctoral programs on performance.

Many of the Australian HDR engineering candidates are enrolled part-time, doctoral and research masters candidates having average loads of 70% and 60% of respectively. Most of the part-time Australian HDR students would be assumed to be in employment related to their research, but their part-time candidature extends the time to completion of their awards. Balancing part-time candidature with engineering employment is usually very demanding for the individual. Most international students are, in contrast, enrolled full-time.

Having a high proportion of international HDR students enriches the international nature of engineering schools. They may well have positive views of Australia, encourage others to undertake research training in Australia, and some may subsequently migrate and take up academic and research career positions in Australia. . However, as graduates, most of them will return to their home countries, taking with them the value of their research training.

The risk in the trends described, and the strong international competition for good graduates for Australia's engineering schools, is that there will be insufficient research training to maintain the level of research needed to support national economic and related goals and needs, and Australia's global competitiveness in engineering research and research-driven innovation. Australian engineering schools need to maintain and grow both domestic and international research degree enrolments.

ACED recommends that the Commonwealth investigate and quantify the return on investment (public and personal) in research training in engineering, and take action to avert the risk of declining research training numbers in engineering, particularly by Australian graduates.

THE EFFECTIVENESS OF THE CURRENT COMMONWEALTH RESEARCH TRAINING SCHEMES

The Commonwealth research training schemes of direct relevance here are:

- the research training scheme (RTS) that allocates (to higher education providers) supported places for Australian HDR students. The original intention of the scheme was to provide funding for sufficient places for all enrolled Australian HDR students, with each institution allocated funds based on research performance, including HDR graduation numbers;
- the international postgraduate research scheme (IPRS) that allocates (to higher education providers) supported places to international students. For 2008 there were 330 IPRS new places allocated across the whole sector;
- Australian Postgraduate Awards (APAs) that allocates (to higher education providers) stipends for Australian candidates taking higher degrees by research. Institutions allocate these on merit, and preferentially to the holders of ARC grants with designated research training components, and full-time candidature in PhDs.
- Endeavour international postgraduate research scholarships provide up to 3 years full tuition and stipends (to maximum value of $158,000) to a small number of overseas research candidates. In 2008 there were 80 of these scholarships for commencing enrolments.

The RTS, IPRS and APA schemes provide valued tuition and stipend support for only a proportion of research training places in engineering.

The average value of each RTS place to any university varies, and each university will have its own funding allocation methodology. An average figure for engineering is likely to be around $20,000. This is intended to support the tuition of the HDR candidate. These include 'direct' costs, such as supervision and laboratory costs, and 'indirect' university-wide support costs such as the library, IT and commercialisation services, and contribute to university-wide services and infrastructure. Supplementary funding from competitive grants, CRC projects, and direct industry support is applied to research student support in most engineering schools. **ACED questions whether the effective value of the funding is adequate to support even the basic needs of an engineering research student.**

The mechanism for allocating RTS funds is also problematic. While ACED has no problem with the principle of performance-based funding, a mechanism that can be more responsive to emerging research priorities would have merit. Many engineering schools have, for example, established new research groupings in emerging areas (see the next section), but the flow through of RTS funding for the specific outcomes of those ventures would take several years of strong performance. That performance has to be built, therefore, from other funds.

Clearly the number of IPRS supported places is insufficient to support more than a very small proportion of the international HDR candidates. In 2006 there were more commencing engineering doctoral students than IPRS places for all disciplines. Furthermore students in IPRS places require further funds to meet their living costs. Those international students without IPRS places or other tuition fee support pay a tuition fee and need to meet their living costs as well. Australia may not remain competitive for international HDR students in engineering without increased number of Commonwealth supported places.

The full-time APA stipend value in 2008 is $20,007. This is inadequate to attract and sustain high-quality engineering graduates. The median graduate commencing salary[6] in 2007 was $50,000, more than double the value of the APA stipend. Some of the most able graduates who might otherwise be prime candidates for research training command salaries double the median.

As presently constituted, therefore, the Commonwealth research training schemes provide only a proportion of the costs of research training in engineering. Universities and engineering schools heavily subsidise their research training from other revenue sources. Additional funds are allocated to supplement stipends (often called top-up scholarships), and to provide more research scholarships (that cover tuition and stipends to different extents) to both Australian and international research candidates. In most institutions these would be allocated preferentially to candidates working on externally funded projects (such as ARC and CRC), and to meet the shortfalls of RTS funding, and APA and IPRS awards. Supporting engineering research training is generally a high priority call on available funding. Much of the supplementary funding referred to above will be taken from revenue derived from coursework teaching, at the risk of under-resourcing the teaching mission of the engineering schools. In short, research training is highly valued and heavily subsidised by teaching.

A small number of very able Australian graduates undertake all or part of their research degrees internationally, some with financial support from Australian Commonwealth schemes. Higher levels of support for such schemes, particularly where as research graduates they return value to Australia would be welcome.

In summary, the current schemes are ineffective for providing sufficient adequately funded places to ensure an adequate and sustainable level of engineering research training (see below). Many engineering faculties win more ARC research grants in engineering and have commitments to CRC programs than their universities have supported places to allocate, particularly to international students.

ACED urges the Commonwealth government to raise significantly the number and value of tuition scholarships and stipends for engineering research for Australian and international graduates. An additional feature of a revised scheme could be to more closely match the number and distribution of fully funded research training places and stipends to Commonwealth project and program funded schemes.

THE ADEQUACY OF CURRENT RESEARCH TRAINING SCHEMES TO SUPPORT AUSTRALIA'S ANTICIPATED REQUIREMENTS FOR TERTIARY-QUALIFIED PROFESSIONALS IN A WIDE RANGE OF DISCIPLINES

As noted above, the RTS, APA and IPRS schemes provide important funding support for research training in engineering schools, but these are insufficient in number and value to support the number of researchers in engineering needed to ensure Australia is competitive in key areas. Such areas include engineering solutions associated with the environment and climate change (including water, energy, and transport); resource extraction and processing, new materials and advanced manufacturing; defence and secure systems, advanced communications and information technology systems; agriculture, and biomedical engineering and health.

Global competition for the best trained minds to tackle these issues is high, and many of the most able doctoral graduates in engineering are attracted overseas. For Australia to retain and strengthen advanced capability requires a signficant increase in the number of research-trained engineers.

ACED urges the Commonwealth to increase the number and value of research tuition scholarships and stipends for Australian and international graduates in key areas of engineering.

ADEQUACY OF TRAINING AND SUPPORT AVAILABLE TO RESEARCH GRADUATE STUDENTS IN AUSTRALIA

Research degrees in Australia are largely constructed on an 'apprenticeship model'; candidates learn research skills by undertaking original work in research-intensive environments. Most engineering schools also offer support in the basic methodologies of literature searching, research proposal formation, and thesis writing.

An increasing proportion of engineering research is being conducted in larger and focussed research concentrations, several supported by the Commonwealth Special and Key Research Centres, and Centres of Excellence programs, and also in Cooperative Research Centres and in NICTA. Access to National Research Infrastructure may also be critical to some research projects. There is no doubt that many engineering doctoral graduates are as good as those from the most prestigious international graduate schools, with whom they compete in their subsequent careers. Nevertheless, the range of research opportunities available to research candidates is limited by the research facilities available and their location.

In general, the quality of training and support available to most engineering research degree candidates is generally adequate to meet the internationally benchmarked standards of the external examination process used in all engineering schools. Most research candidates in engineering will have access to travel funds for national and international conferences during their candidature. As noted above, these funds may be provided by research project and program funding, or through cross-subsidy from other revenue available to the engineering school or research concentration.

Many members of ACED would argue that some specialist technical coursework should be introduced into engineering research degrees both to bridge the 'gap' between the content of engineering bachelor degrees and contemporary leading edge content in the chosen research areas, or to broaden the range of expertise of the research candidate. Advanced coursework topics might best be provided on a shared basis between participating engineering schools. Including substantial coursework requirments would extend the duration of the research degree, and match more closely the duration of research degrees in Europe and America.

Some universities are also offering or requiring research candidates to undertake some studies in the processes of innovation and commercialisation. Such programs have been developed and introduced into a number of Australian universities, and ACED endorses this development strongly. A recent example offering the promise of increasing the number of PhD graduates with relevant skills in commercialisation is the extension of the ATN Universities' Graduate Certificate in Commercialisation, offered through their e-Grad School, to all PhD candidates in the Cooperative Research Centres program. Over time this has the potential to significantly increase the awareness of the innovation process in early career researchers proceeding to industry and university appointments.

ACED recommends that consideration be given to fully funding research places to include appropriate graduate coursework options to enhance the existing PhD programs and improve the capacity of PhD graduates to contribute to innovative research and business productivity.

FACTORS FOR GRADUATES THAT DETERMINE PUSUIT OF A CAREER IN RESEARCH

As noted earlier, the standard research stipend offers no financial incentive for a typical Australian first-degree engineering graduate to undertake research.

The decision to undertake research is most likely to be a mixture of interest in the research topic area and interest in a career in a research-driven environment. Australia offers the latter primarily in universities, CSIRO, DSTO, ANSTO and a small number of high technology companies. Some of the latter may be partners in ARC Linkage projects, and CRC programs. As noted earlier, Australia has relatively few high-profile research-led engineering companies.

Particularly at the present time of high demand for graduate engineers, research-based careers may be perceived to be more demanding, less rewarding and less secure than those in other areas of professional engineering: consulting, design, construction, systems integration, production, maintenance, etc. Most first-degrees in engineering (typically four-year Bachelor of Engineering awards) are more strongly oriented to industry practice, rather than research.

Nevertheless, all engineering degrees contain advanced engineering science and discipine specialisation, and significant project work, particularly in final-year. Much of this is derived from academics' research, and some students publish with their supervisors. Like other professional disciplines, engineering does not operate with a research-intensive 'honours year', perhaps limiting the visibility of research opportunities, compared with science degrees, for example.

After four years of undergraduate study (or five or more, if engineering is taken as a dual degree with science, management, arts, law, etc. or with a significant period studying on industrial placement) more than 90% of the graduates are keen to develop their careers with good remuneration in industry, rather than undertake more study and defer starting a salaried position. Furthermore, many engineering graduates have already obtained part-time positions with companies with whom they have had industry experience, well before graduation. Nearing their mid-20s, relatively few seek the career uncertainty and low salary of research.

There are, however, some industry sectors, such as defence, where companies are seeking and supporting their staff to gain higher level skills through research degrees. Such 'mainstreaming' of research skills into more industry sectors would increase both the innovative capacity of those sectors and the take up of research in the universities.

OPPORTUNITIES FOR CAREER ADVANCEMENT FOR RESEARCH GRADUATES AND STAFF

Table 4 shows that the number of academic ('teaching & research') staff in the engineering schools has declined over the past decade, while the number of research staff has grown. The latter growth is linked to increases in research funding under Commonwealth initiatives such as Building Australia's Future. Some of these new research positions do not, however, require doctorates, although their incumbents may also be enrolled in higher degrees on a part-time basis. It could be argued that this growth partly balances the downturn in Australian enrolments in higher degree research. (A low-level research position is remunerated slightly lower than the median graduate starting salary for engineers, but is a much better salary than an APA stipend.)

Research graduates and research-only staff, particularly those with engineering PhDs, have many good career opportunities in Australian universities, research organisations, and some Australian industries. Within universities, however, most research-only staff work on short-term contracts, usually of less than 3

years duration, and dependent on the research funding won by the 'permanent' academic staff in 'teaching and research' positions. Contract research staff are also limited in their eligibility to apply for research funding in their own names, under the ARC Discovery and Linkage grant schemes, for example, although the recently annnounced Future Fellowships scheme for mid-career researchers will provide new opportunities for some staff in these positions. In general, salaries for engineers in academic and research positions do not compare well with those offered in industry. Furthermore, most engineers progress towards management roles within 5 – 10 years from first-degree graduation, rather than progress their careers through advanced technical and research-based work.

Taken together, the career uncertainties and poor rewards for research lead some able engineering researchers away from what they may do best, or they seek opportunities overseas in companies that appear to be more innovation-led than in Australia. ACED members hear stories of PhD holders being regarded as 'overqualified' and 'too specialised' for Australian industry needs. It may also be that in their great desire to recruit engineering graduates, companies place too little value on the extra learning and skills that a PhD provides.

Research-oriented staff in 'teaching and research' positions may lose previous research momentum due to excessive teaching and administrative loads, and lack of numbers of higher degree research students and research funding support. The recent review (ref 5, p 43) noted that the average student-staff ratio for teaching in engineering had increased from 14 to more than 21 over 1996 – 2006; that technical support staffing had declined, and that the high competitiveness of ARC funding is a high entry barrier for new academic staff. The effective higher degree research supervision load is about 4,000, for at least 2,000 potential research supervisors (that is, most of the 1,648 teaching & research academics plus a proportion of the research-only staff). Many would argue that the HDR supervision capacity would be at least 8,000. Having such a number of well-qualified and well-supported and HDR students in engineering would undoubtedly strengthen Australia's engineering research.

The recent review (ref 5, pp 95-100, and Recommendation 5) proposed that there should be closer working between the engineering schools and industry with, for example, a greater number of joint university-industry appointments. These would enrich the engineering curriculum, ensuring contemporary industry issues are brought into the classroom, and potentially enhance the innovation and research capacity of the company. Such joint appointments could be implemented at all career levels.

ACED recommends measures to increase the incentives and rewards for engineering research graduates and staff to remain in university positions, improve the opportunities for research-only staff to develop their careers, and to increase the number of joint university-industry appointments.

FACTORS DETERMINING PURSUIT OF RESEARCH OPPORTUNITIES OVERSEAS

Some Australian first-degree engineering graduates undertake their doctoral research overseas, funded by prestigious scholarships offered by American and UK universities, and the attraction of international experiences.

Doctoral graduates and established academic and research staff may also be attracted to take up opportunities overseas, in organisations and universities with greater career and research opportunities than Australia can offer. Some of these opportunities will be in the research arms of global companies that have commercial, but not research operations in Australia.

AUSTRALIA'S ABILITY TO COMPETE INTERNATIONALLY FOR HIGH QUALITY RESEARCHERS

Effective competition for high quality research students and research staff requires having world-class research environments (laboratories and supervision), and competitive rewards, such as scholarships, remuneration and career opportunities.

Many of the engineering-oriented Centres of Excellence and CRCs meet the 'world-class' criterion. The challenge within higher education as a whole is to raise the standard across the system to world-class levels, and reverse trends such as the rising student-staff ratio, that erodes the research time of many engineering academics.

The second requirement is to institute sufficient international scholarships, incentives and rewards to compete internationally. The recent increase in the value of the $A has made Australia less price competitive than five years ago for students paying fees. Furthermore, there are generally low numbers of scholarship funds available within Australia, as discussed earlier in this submission.

As the data presented earlier shows, Australian engineering research is increasingly dependent on international students. Approaches that could increase Australia's competitiveness for HDR students include having increased opportunities for international students to undertake some of their research in their home countries, thereby building up international links; and increasing the number and value of industry-linked research scholarships, especially with companies that operate in both Austrlaia and the international student's home country.

Australian engineering schools are already attracting many international research staff, although the conditions of employment (see above) are not necessarily as attractive as elsewhere. Research-qualified engineers could arguably be a special category for skilled migration.

ACED recommends that measures are instituted to attract high quality international research students and staff, through scholarships, fellowships, industry-linked exchange programs, and enhanced migration status.

WHETHER AUSTRALIA'S ACADEMIC WORKFORCE IS AGEING, AND ITS IMPACT ON RESEARCH CAPACITY

As Table 4 illustrates, the staffing balance in Australia's engineering schools has changed towards research over the past decade, and as a result the median age over all academic staff has probably not increased markedly.

However, the recent review (ref 5, pp 84 -86) reported that there were several areas of critical concern. These include mining and resource engineering, and some schools and disciplines where the staff are nearing retirement and lack of funding has limited succession planning. Without adequate research leadership, research capacity will certainly be compromised.

Further, the recent review (ref 5, pp 60 – 61) reported on the low participation of women as engineering students, in academia and in the engineering workforce in general. It is evident (Table 4) that the proportion of women amongst research and academic staff is increasing, albeit from a very low base. Women now form approximately 20% of the commencing research student cohort. The apparent success in recruiting women into research and academic positions in engineering needs to be actively supported in terms of both enhancing their opportunities and meeting their career aspirations, and to provide further role models for prospective female undergraduate engineering students.

The review (ref 5, Recommendation 6) proposed a number of measures to address skills shortages in engineering by providing and supporting additional educational pathways for attracting and re-training women and other under-represented groups. While not addressed specifically in that recommendation, providing additional support for women on engineering research pathways would clearly enrich and strengthen engineering in Australian universities.

ACED supports measures to increase the enrolment and retention of women in research degrees, and as research and academic staff.

Tables and References follow

Tables

Table 1 Total enrolments (persons) in higher degrees by research in engineering, 1996 - 2006

	1996	1998	2000	2002	2004	2006	% change 1996 to 2006
doctorate							
Australian	1,771	1,866	2,042	2,620	3.001	2,935	65.7
international	548	505	489	754	984	1,264	130.1
total	2,319	2,371	2,531	3,374	3,985	4,199	96.3
research masters							
Australian	1,068	964	850	952	927	786	-26.4
international	255	217	194	260	360	428	67.8
total	1,313	1,181	1,044	1,212	1,287	1,214	-8.5
total for all HDR	3,632	3,552	3,575	4,586	5,272	5,413	49.0
% international	22.1	20.3	19.1	22.1	25.5	31.3	

data: derived from reference 5, sourced from DEEWR

Table 2 Commencing enrolments (persons) in higher degrees by research in engineering, 1996 - 2006

	1996	1998	2000	2002	2004	2006	% change 1996 to 2006
doctorate							
Australian	449	491	556	614	687	486	8.2
international	143	164	176	226	264	361	152.4
doctorate total	592	655	732	840	951	847	43.1
research masters							
Australian	395	362	330	366	346	257	-34.9
international	129	114	112	140	203	178	38.0
res masrters total	524	476	442	506	549	435	-17.0
total for all HDR	1,116	1,131	1,174	1,346	1,500	1,282	14.9
% international	24.4	24.6	24.5	27.2	31.1	42.0	

data: derived from reference 5, sourced from DEEWR

Table 3 Graduations from higher degrees by research in engineering, 1996 - 2005

	1996	1998	2000	2002	2004	2005	% change 1996 to 2006
doctorate							
Australian	291	325	355	381	421	452	55.3
international	122	113	116	97	108	185	51.6
doctorate total	413	438	474	480	570	637	54.2
research masters							
Australian	178	164	143	144	147	133	-25.3
international	59	66	46	41	73	75	27.1
res masters total	237	230	189	185	220	208	-12.3
Total for all HDR	650	668	663	665	790	845	30.0
% international	27.8	26.8	24.9	21.1	28.1	30.8	

data: derived from reference 5, sourced from DEEWR

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: ref 5, source DEEWR

References

1 ACED 2004, extracts from the Constitution, Australian Council of Engineering Deans, revised 2004

2 Royal Academy of Engineering 2007, *Educating Engineers for the 21st Century*, Royal Academy of Engineering, UK, London

3 Auyang, S Y, 2004, *Engineering: an endless frontier*, Harvard University Press, Cambridge Mass.

4 Forrester, T (ed.), 1985, *The Information Technology Revolution*, MIT Press, Cambridge Mass.

5 King, R , 2008, *Addressing the Supply and Quality of Engineering Graduates for the New Century*, discipline-based scoping report for the Carrick Institute for Learning & Teaching, http://www.altc.edu.au/carrick/webdav/site/carricksite/users/siteadmin/public/Grants_DBIprojec_engineeringquality_project%20report_25march08.pdf

6 GradStats, No 12, December 2007, Graduate Careers Australia