Australian Council of Engineering Deans

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Innovation and Science Australia

ACED Response to the 2030 Strategic Plan Issues Paper

I write on behalf of the Australian Council of Engineering Deans (ACED), the incorporated association of the 35 Australian universities providing externally accredited engineering degree programs. ACED's mission is to support and promote engineering education and engineering research in the higher education sector. Most of the ACED member faculties have responsibilities for computing and IT education and research. While the emphasis of this response is on engineering, many of its points are relevant to the other areas, as included.

ACED welcomes this opportunity to contribute to the development of the ISA 2030 Strategic Plan. We believe that engineering must be a key discipline in the formulation and implementation of the plan. Australia's university-based engineering education, research training and research are performing well against national and international measures, and can be further improved to enhance and support Australian innovation.

We provide five key points, five perspectives on engineering and innovation in Australia, and address each of the Challenges identified in the Issues Paper. We have appended the recently published ACED Factsheet on higher education and research in the Australian Higher Education sector.

Key points -

1. Engineering, as a discipline and profession, has explicit responsibilities for the implementation of innovation in physical and information systems that serve the community and add value. Making this value more explicit in public discourse will contribute to acting on the following points.
2. Australia must significantly increase the numbers of domestic graduates with first degree qualifications in Engineering, Computing and IT qualifications. Increasing the number of women to parity with men would be a substantial achievement in this direction.
3. First-degree curricula in engineering must be continually reviewed and adapted to deliver a balance of fundamental science, leading edge technology, and employability skills, for diverse careers and unknown futures. A range of degrees is needed to satisfy the diversity of practice. Much has changed since the last national review of engineering education in 2007-08, and ACED would be keen to work with ISA and other organisations to establish a forward looking review.
4. The Australian school curriculum must be strengthened in areas of technology and engineering, and encourage curriculum interventions that emphasise STEM-based creativity and innovation.
5. Public funding, to be matched by industry contributions, should be increased for CRCs and industry growth centres and clusters in key areas of strength and potential, such as high value agriculture, wireless telecommunications, AI applications (e.g. field robotics), minerals processing and new materials, automation in construction and infrastructure management, water resource management, renewable energy and management, and new manufacturing.
6. Strengthen Australia's industry innovation capacity through stronger collaboration with the university engineering faculties and schools on leading edge engineering science, technologies and innovation practice. Potential areas for collaborative development could be new user-driven postgraduate coursework programs and new models of industry linked research training.

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Background perspectives

Australia's engineering education and research: higher education outputs[1].

Coursework programs: in 2015, the Australian higher education system graduated 17,688 students (approximately 40% international), mostly with 4-year Bachelor of Engineering (Honours) degrees. Engineering graduates made up 5.7 % of the national total of Bachelor degrees awarded to domestic students, and 3.5% of the national domestic postgraduate total.

Research training: in 2015, the universities produced 1,488 research higher degree (HDR) graduates (approximately 52% international), mostly PhD's. The international proportion of commencing HDR candidates is steadily increasing. Engineering was the field of study of 10.6 % of the national domestic HDR graduate total.

Research: in 2013, the ACED member faculties and schools reported $375M total external research income, of which their $34.5M for CRC income was one third of the national total in this category. Engineering won more than 30% of the patents granted to the Australian universities over 2011-13. The 2015 Excellence in Research Australia (ERA) report identified three-quarters of the ACED members' universities having at least one area of engineering rated at level 4 (above world standing), while 6 had five or more rated at level 5. Materials engineering and electrical & electronic engineering featured most strongly.

Country comparisons: Australia has relatively few engineers in the workforce

Whilst engineering has a sound presence in Australia's higher education system, country comparisons indicate that the national capacity in engineering is relatively low.

In 2012, Australia had 12% of its tertiary-educated adult workforce (aged 25 - 64) with initial qualifications in "*engineering, manufacturing and construction*". This proportion is well below the OECD average of 18%, and put Australia 26th out of 28 OECD counties listed[2]. By comparison, Sweden, Japan and Germany had, respectively, 18%, 19% and 29% of their adult workforce educated in the engineering-related areas. (The OECD data tertiary education includes all post-secondary qualifications, including trades and diplomas. The latter are delivered in Australia by the VET sector.)

Australia has relatively high numbers of science graduates, compared with those from engineering. Nevertheless, in 2012 Australian had 10% of the tertiary-educated adult workforce with qualifications in "*science, mathematics and computing*", slightly below the 11% OECD average, and at 17th place. This low position is probably largely due to relatively small numbers of graduates in computer science and information technology, compared with other countries.

The 2013 Global Innovation Index[3] ranked Australia 19th (out of 142 countries), but 7th overall for the human capital and research scale. Within the latter, however, the proportion of graduates in science (including computing) and engineering was ranked 73rd, demonstrating further that Australia must not further reduce its production of graduates in STEM fields.

These numbers indicate that the relative size of the Australian workforce in engineering, computing and IT is limiting the national capacity for competitive technological innovation.

Engineering has key roles in innovation

Engineering is a socio-technical domain with leading responsibilities to implement the design, production, operation and retirement from service of complex physical and information-based products, systems and infrastructure. New engineered products, systems and infrastructure are expected to deliver their purpose and performance, defined by human and organisational needs. Engineers aim to provide best possible solutions under the constraints of human resources, physical

[1] *ACED Factsheet*, April 2017, is appended to this submission
[2] OECD (2016), *Education at a Glance 2016: OECD Indicators*,
[3] Cornell University, INSEAD and WIPO (2014), *Global Innovation Index 2014: The Human Factor in Innovation*, Fontainebleau, Ithaca and Geneva

and information resources, cost and environmental impacts. Engineering practice is manifestly inter-disciplinary and multi-disciplinary, with links to most areas of human knowledge and endeavour.

Engineers combine established practice and experience with new technologies, new materials and new methodologies. Engineers in industry, as well as those in academic and research practice, contribute new engineering science, and to improving methodologies of practice. Engineers thereby contribute to innovation both through new ideas and by delivering value through executing their and others' ideas[4].

Engineering education and research training

Engineers' initial education and training embodies scientific fundamentals, engineering practice, and the development of personal and professional attributes for practice. All accredited degrees include links with industry through work placements, projects, and guest lecturers, etc., and basic understanding of business practice and project management. Australian engineering education is formally benchmarked against international standards. Graduates' employability skills are recognised by employers, and engineering coursework graduates have higher median employment rates and higher median starting salaries than their peers from almost all other disciplines.

Advanced coursework degrees offer more specialist technological knowledge and/or extend capabilities for engineering practice. HDR training mostly contributes new engineering science, often with potential innovation in mind, although some advances engineering practice, including in systems thinking. Many HDR engineering graduates seek careers in industry (rather than academia); and they should become leaders in the future innovation system.

"Engineering" could be more strongly articulated in Australia's innovation discourse

The public realisation that engineering is critical to a more innovative future Australia could be enhanced by changes in language. For example, more use of the phrase "*science and engineering*", as in USA and UK, would emphasise the complementarity of science – (as discovery and knowledge extension), and engineering (as value-delivering technological application). The collective term "*science*" does not adequately express what engineers do, especially in delivering useful outcomes and economic value from innovative ideas. The meaning of "*STEM*" is often highly contextual.

Specific responses to the ISA Issues Paper and Challenges

ACED is in complete accord with the overall context and vision, trends and opportunities expressed in the Issues Paper. Our responses are intended to underpin practical initiatives to realise the 2030 vision, with performance and progress capable of being tracked with suitable parameters and metrics.

ACED strongly urges reinforcement of all of the current strategies in the *National Science and Innovation* (NISA) program.

In framing our responses to the specific Challenges, ACED emphasises two areas for action:

(i) Increase the funding and scope of the CRC and industry growth centre and cluster programs. These politically bi-partisan and proven programs should continue to be the flagships for industry-university R&D and innovation collaboration. They have high potential to spawn new companies, share capital resources, and stimulate growth in areas of STEM-based education at school and tertiary levels, as well as research.

(ii) Increase the numbers of Australian students taking up tertiary education in Engineering and IT towards matching those of other countries. Doubling the current numbers (and proportion) of first degree graduates over a decade in these fields would be in order. Reaching gender equality in participation in Engineering and IT degrees (without reducing the number of males) would contribute substantially to such a target. Specific issues and priorities for changes in school and tertiary education are discussed in our response to Challenge 3.

[4] S Poole (2017) *Ideas and Execution: The Yin and Yang of Innovation*, NSW Science & Research Breakfast Seminar, Parliament House, 1 Feb 2017

Challenge 1: Moving more firms, in more sectors, closer to the innovation frontier

ACED agrees with the attributes stated for the imagined highly innovative Australia. Three priority responses would be to:

- encourage (e.g. with tax incentives) leaders in existing firms to engage more strongly with the university sector, in education, training and research and in all discipline areas, and with multi-disciplinary mindsets;
- encourage universities to increase cross-disciplinary exposure of their first degree programs in all areas, particularly in their senior years, and in innovation-oriented project work (see Challenge 3). This would potentially increase the innovation capacity of firms in all sectors;
- encourage universities to develop broader skills in PhD engineering graduates to complement their deep research skills (see Challenge 4). These graduates should be innovation leaders, creators of new start-ups and new technology companies, enabling greater flow of people across academia and business.

Challenge 2: Moving and keeping Government closer to the innovation frontier

Again, the imagined future is sound. The loss of public service technical expertise due to privatisation of many engineering services (in energy, water, etc) has clearly had negative consequences. As highlighted in the paper, the Defence model should indeed be a strong exemplar. Whilst Governments must partner with business to deliver new services, appropriate processes have to be in place to ensure performance and value. The scale, complexity, and expected lifetime of major physical and information infrastructure must allow for continued improvement through innovation.

Four priority responses would be to:

- encourage recruitment of more STEM graduates into the public service, and ensure that they have strong career paths that also require them to maintain specialised knowledge that relates to innovation;
- provide incentives and/or programs for HDR candidates to take placements in Government agencies to promote insourcing and innovation;
- increase the number of CRCs and industry growth centres in areas related to delivery of Government and public services. This would support and deliver more innovation and more HDR graduates with relevant expertise and capabilities to innovate in existing organisations and to create new firms;
- encourage Government procurement units to include provision for innovation in major future public infrastructure. Managing this would require increased capacity and confidence to evaluate innovation in tender responses. Successful bidders would be required to demonstrate innovation outcomes and processes that will improve performance and value over the project lifetime, while also evaluating corresponding risks;

Challenge 3: Delivering high-quality and relevant education and skills development for Australians throughout their lives

The contents of the three points of the imagined future are aspirational, relative to the current performance of our education system as a whole. Nevertheless, most of the elements of the system are in place to underpin developments towards the desired aims. As noted earlier, Australia produces fewer engineers (and IT graduates) than most comparable countries. To address some of the points quickly would require transformative actions and resources.

ACED would also favour a comprehensive consultative review, such as those undertaken in 1995-6 and 2007-8 to establish strategic directions and specific programs for engineering program development. The following priorities are aimed at enhancing engineering students', employees' and employers' capacities to contribute to a more innovative workforce:

<u>for school education</u>:

- roll-out the Australian National Curriculum in all states and territories as rapidly as possible. Further develop cross-curriculum (integrative) work in STEM (including in the *Technology* subject area) that can be linked to topics in business, to increase school students' understanding of innovation;
- address the decline of participation by women in most STEM subject areas, by demonstrating relevance and potentially strong career paths, and by encouraging the reduction of gendered language and unconscious gender bias in society at large;
- mainstream programming skills and understanding of data as rapidly as possible, to develop students' understanding of logic and creative thinking, and computational skills, as included in the *Digital Technologies* area of the *Technology* subject area;
- encourage the specification of Year 11 and 12 subjects in the *Technology* subject area that build on the F–10 syllabus topics in systems thinking, sustainability, new technologies and innovation; encourage take-up of senior *Technology* subjects by students of both genders;
- train more primary school teachers in STEM; require all secondary teachers in the STEM subject areas to possess a first degree in their subject area, and to have regular professional development in both their subject area and contemporary teaching methods, delivered by their local higher education provider and industry partners.

<u>for tertiary and higher education:</u>

- increase and improve the engagement with industry[5] and innovation in engineering, computing and IT qualifications. Initial qualifications in computing and IT may benefit from extending their duration to embrace stronger employability skills (as in the 4-year Engineering degrees). Both areas must attract larger enrolments, particularly by women, by focussing more on their potential for human-centred problem solving, than on pre-requisite knowledge;
- re-examine and reverse the decline of participation by women in most STEM disciplines, including engineering[6], by improving degree programs to focus more on employability outcomes and careers, and by increasing cross-disciplinary content, including with business. Such improvements will benefit all students;
- in engineering education, increase the connections between theory and practice, increase the curriculum emphasis on problem-finding and problem-solving, cross-disciplinary studies and innovation, to improve graduates' flexibility and adaptability;
- in engineering education, revisit the needs of industry with respect to the complementary roles of technicians, technologists and professional engineers, with a view to improving the matches between qualifications and educational provision by the VET and university sectors;
- in engineering education, work with engineering employers to identify topics of contemporary importance to innovation, that can be provided to undergraduates and postgraduates in short-course on-line formats;
- ensure contemporary and flexible best-practice education methodologies are used, by encouraging local action, and (with national funding) collaborative projects and fellowships, such as those previously run by the Government's Office of Learning and Teaching, and require universities to report on the effectiveness of improved teaching practices;
- with an increasing number of CRCs and industry growth centres and clusters (as proposed earlier), ensure that undergraduates and postgraduates in engineering have opportunities to

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[5] ACED Position Statement, *Promoting engagement between industry and universities for improving engineering graduate capabilities and accelerating innovation*, Dec 2016. https://www.engineersaustralia.org.au/sites/default/files/content-files/ACED/position_statement_no_1.pdf

[6] ACED Position Statement, *Increasing the Participation of Women in Engineering Education*, March 2017. https://www.engineersaustralia.org.au/sites/default/files/resource-files/2017-04/POSITION%20STATEMENT%20No%202A%20Promoting%20women%20in%20engineering%20education.pdf

take work experience or undertake related project work in them, that has potential for further commercial development;

- encourage the development of advanced coursework programs (for award, and non-award) in engineering technologies and advanced practice, that can support employees in industry clusters in key areas, as well as full-time students. We envisage that many of these programs and coursework units would be designed and modularised for on-line delivery, and developed by collaborations between universities and between universities and industry (see next point).

For employers (and Governments):

- encourage, or require employees in the STEM areas to engage with their professional communities and networks (including the education sectors), to maintain their knowledge and skills at the leading edge of practice and innovation in their area. This could be facilitated by pay-roll tax or similar measures.

Challenge 4: Maximising the engagement of our world class research system with end users

The vision is sound, but will be difficult hard to realise.

Australia, generally, has a divide between engineering researchers in universities and business. This is somewhat exacerbated by the difficulties many academics who are newly appointed from overseas have in making contact with industry and business. While more active networking would overcome this, the incentives for collaboration need to be increased. On the other hand, Australia has a highly internationalised engineering workforce, not least in its universities.

ACED would encourage universities to increase the weighting for industry experience and engagement in academic staff appointment and promotion criteria.

While much of Australia's engineering research is world class, we have fewer large engineering companies to work with than many countries with which we compete. We envisage that growth in innovation activity and outcomes in Australia's engineering industries will emerge at least as much from commercialisation of home-grown research as from collaboration with existing large multinational companies, whose research capabilities are likely to be overseas. This enhances the need for our researchers to work with SME's and across international boundaries.

As in other areas of this response, having more engineering CRCs, industry centres and clusters for advanced manufacturing and other key areas in which innovation is realised by engineering, would enhance more local engagement between Universities and end users.

On research training, it is of great concern that the number of Australian HDR candidates in engineering is not increasing strongly. Anecdotally, we hear that some engineering PhD's do not declare their higher degree when applying for jobs, in case they are considered to be "*not practical or to be overspecialised*". This is a travesty for them and a potential lost opportunity for the company. ACED members would want to hear no more such cases, and indeed encourage more companies to recognise the enhanced skills that HDR graduates should have.

PhD candidates in engineering should be treated as professionals (as are their graduate peers in industry) but on specific tracks to be innovation leaders and entrepreneurs. They should be strongly supported by high quality resources and equipment.

To deliver enhanced employability skills and well as advanced engineering knowledge within HDR programs, coursework should become more common in areas of advanced specialisation (including via inter-institutional enrolments), and in such areas as entrepreneurship and innovation management. This would extend the duration of a PhD, but would reap great rewards for the candidate and his/her future career, and the economy as a whole. The current regulatory and funding constraints that limit coursework in HDR programs should be reviewed.

Alternative models of industry-related research training that contain interdisciplinary exposure and industry engagement should be trialled in Australia. One such model is the Engineering Doctorate offered by the 19 Industrial Doctorate Centres[7], supported by the ESPRC in UK. In this, companies compete to recruit the best HDR candidates for their research. Australian Government funding to initiate a similar program would enhance the industry awareness of the value of a PhD and also expose academia to more opportunities in applied research.

While many of the international HDR candidates will return to their home countries, many will want to stay in Australia, and we will continue to need them. The barriers to their employment in industry or academia, such as those exercised through visa restrictions, must be minimised.

Challenge 5: Maximising advantage from international knowledge, talent and capital

The vision is well stated, and geo-politics permitting, is realisable through good domestic and international trade, business, immigration and educational policies.

Overall, there are few reasons to believe that Australia's general attractiveness as a relatively wealthy, democratic, free-market, open, multi-cultural, and probably resilient society will change fundamentally over the next decade. To continue to attract international talent we shall have to be able to demonstrate leading edge performance in science and innovation. Australia can do that over a relatively narrow front.

ACED's response to this challenge are that Australia:

- must focus on the particular value we can add to global value chains. With an increasingly well-educated global workforce, not least in engineering, our services and products will need to be of very high quality;
- must specialise its engineering expertise in areas of strength, such as bio-tech and health technologies, high value agriculture, wireless telecommunications, AI applications (e.g. field robotics), minerals processing and new materials, automation in construction and infrastructure management, water resource management, renewable energy and management, and new manufacturing.

Challenge 6: Bold, high-impact initiatives

ACED supports the notion of having a number of bold visions, as they will lift aspirations of individuals (including young people) and organisations, as well as deliver huge direct and indirect value. There are however, Australian tendencies to "knock" achievement and achievers, and to underinvest in potential, at critical times in the innovation cycle. As engineers, we recognise that ongoing changes in global manufacturing require us to produce outstanding quality and value physical products.

We would strongly urge identifying bold challenges that build on expertise and that have high positive impacts on people and sustainability. The challenges must have bi-partisan political support.

Potential for bold initiatives in which engineering would play major roles lie in the following sectors:

- Medical Technology. Local and global needs are likely to grow. It is multi-disciplinary (including many areas of science, engineering and IT) and a proven area of Australian strength. There is a group of SMEs that are very competitive, we need to take the next step to grow at least five multi-nationals from this field.

- Space Science and Engineering. Australia has latent capability to develop an Agency to develop an earth observation satellite to serve Australia's growing need for the autonomous surveying of our land mass and borders, for disaster management, defence, agriculture and environmental monitoring. Continued reliance on other countries' satellites is risky and unsatisfactory for a country of Australia's geography and economy. Committing to building our own satellites would advance research and technical developments in Australia, and provide substantial economic, academic, strategic and political independence at a relatively small cost. (More information on this can be provided if required.)

[7] Engineering and Physical Sciences Research Council, *Engineering Doctorate*. https://www.epsrc.ac.uk/skills/students/coll/engdoctorate/ downloaded 19/05/17

- Renewable Energy Technologies and Systems: looking to the long-term carbon-free future, and our geography, Australia has potential to develop multi-modal solutions, combining wind, solar, tidal, hydro and wave energy sources, and a range of storage methodologies, with sound systems engineering.

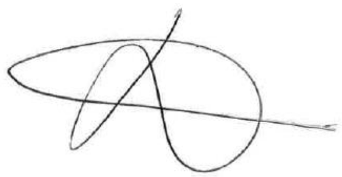
Conclusion

In aligning with the bold future envisioned in the Issues Paper, ACED is mindful of the huge efforts that the professional science, engineering, technological and business communities have put into their statements and reports on research, innovation, STEM education and related matters, over many years. Their impact has been more incremental than transformative.

ACED's desire to see all aspects of the Australian tertiary education sector expand significantly goes beyond its own interests. Ultimately our prosperity and well-being as a nation will depend on it. We look forward to making further contributions to the development and execution of the plan.

ACED will be pleased to provide further information as required.

Yours sincerely



Professor John L Wilson
ACED President

Appendix: ACED Factsheet, April 2017

Australian Council of Engineering Deans Inc.

Australian Engineering Education Factsheet — April 2017

An update on the status and trends in Australia's higher education system for engineering

Introduction

Australia has a mature university-based engineering education system that produces graduates qualified to commence supervised practice, and advance their knowledge and skills. The system provides higher degree research training and undertakes research in engineering science and practice. This Factsheet provides a national snapshot of the system, using the most recent national data.

System Size

Currently 35 public universities, several TAFE Institutes, and a small number of private colleges are providing higher education (HEd) qualifications in engineering[8] at levels 6-10 of the *Australian Qualifications Framework* (AQF).

Overall, in 2015, engineering had 106,210 enrolled students, some 7.5% of total national higher education enrolments. International students constitute 35.9% of the enrolments in engineering qualifications. The total 'engineering load' in 2015 was 71,201 equivalent full-time students, taking into account students' study patterns.

In 2015, there were more than 4,200 full-time equivalent academic staff (18% women) in the university engineering faculties and schools. Approximately 1,800 of the staff were in 'research-only' positions.

Coursework Programs

Engineering graduate numbers from each of the principal award categories, for 2005, 2010 and 2015, were:

<table>
<tr><th rowspan="2">award level</th><th colspan="2">2005</th><th colspan="2">2010</th><th colspan="2">2015</th></tr>
<tr><th>Dom</th><th>Int</th><th>Dom</th><th>Int</th><th>Dom</th><th>Int</th></tr>
<tr><td>Masters</td><td>635</td><td>2,299</td><td>1,024</td><td>2,660</td><td>1,543</td><td>3,205</td></tr>
<tr><td>Other PG</td><td>363</td><td>195</td><td>672</td><td>279</td><td>848</td><td>160</td></tr>
<tr><td>Bach (4-yr)</td><td rowspan="2">5,680</td><td rowspan="2">2,396</td><td>5,775</td><td>2,571</td><td>7,219</td><td>3,239</td></tr>
<tr><td>Bach (3-yr)</td><td>452</td><td>395</td><td>524</td><td>251</td></tr>
<tr><td>Ass Deg/AD</td><td>141</td><td>49</td><td>320</td><td>97</td><td>570</td><td>129</td></tr>
<tr><td>TOTALS</td><td>6,819</td><td>4,939</td><td>8,243</td><td>6,002</td><td>10,704</td><td>6,984</td></tr>
</table>

Commencing student numbers for the same years were:

award level	2005		2010		2015	
	Dom	Int	Dom	Int	Dom	Int
Masters	876	2,579	1,541	2,770	2,091	5,473
Other PG	1,103	260	1,132	315	844	177
Bachelors	9,916	3,782	12,541	6,626	14,896	6,510
Ass Deg/AD	419	149	1,357	157	1,178	196
TOTALS	**12,314**	**6,770**	**16,571**	**9,868**	**19,009**	**12,356**

These data show:

- growth in domestic commencing enrolments in Bachelor degrees that is in line with the growth of total domestic commencing enrolments;
- expansionary growth in international enrolments in Master (ME) degrees, particularly into new, accredited, 'entry-to-practice' programs (see below).

The average **graduation rate** for students commencing an engineering Bachelor degree is approximately 65%. Graduation may be from a different institution than that of commencement, and may be up to a decade later, allowing for part-time study and study breaks.

The **basis of admission** of domestic students into Bachelor degrees has diversified over time. As the total number of commencements has increased, relatively fewer enter on the basis of schooling, and more have prior HEd studies:

Basis of Admission	2004	2011	2015
secondary school	71.1%	64.9%	58.3%
VET/TAFE	6.8%	7.4%	6.5%
higher education	14.4%	18.5%	22.5%
other	7.7%	9.0%	12.7%

External accreditation by the professional body, *Engineers Australia*, is valued by providers. The accreditation standards are set by the practicing profession, and are benchmarked to international agreements[9].

Since 1980, the standard accredited *professional engineering* qualification has been the 4-year degree, often awarded with a class of Honours. Since 2014, providers have made these degrees compliant with the requirements of the AQF level 8, Bachelor (Honours) degree specification.

Since the mid-2000's, an increasing number of providers have offered ME degrees that are accredited for entry-to-practice at the level of professional engineer. Two universities have ceased offering BE(Hons) degrees. Most of their students commence university study by taking the engineering major in a Bachelor of Science degree.

Three-year Bachelors degrees and 2-year Associate Degrees (and Advanced Diplomas) may be accredited at the qualification levels for the occupations of *engineering technologist* and *engineering associate*, respectively.

Bachelor degree commencing numbers for engineering therefore underestimate the numbers heading for an engineering qualification. The Master graduate numbers combine those from entry-to-practice degrees and from Masters degrees designed for qualified engineers.

[8] The data are for the field of education *Engineering and Related Technologies*. This includes civil aviation and surveying, areas that have small student enrolments.

[9] The Washington, Sydney and Dublin Accords, of the International Engineering Alliance. http://www.ieagreements.org/

The participation of women in engineering coursework programs has not increased substantially over the decade, indicated by these figures for commencing students:

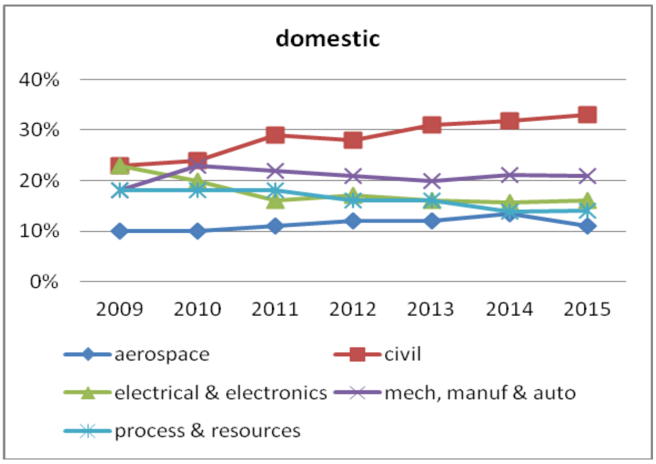
	2005		2010		2015	
	Dom	Int	Dom	Int	Dom	Int
Masters	17.0%	16.9%	16.7%	20.0%	18.7%	20.3%
Bachelors	12.7%	17.7%	14.4%	15.1%	15.2%	21.0%

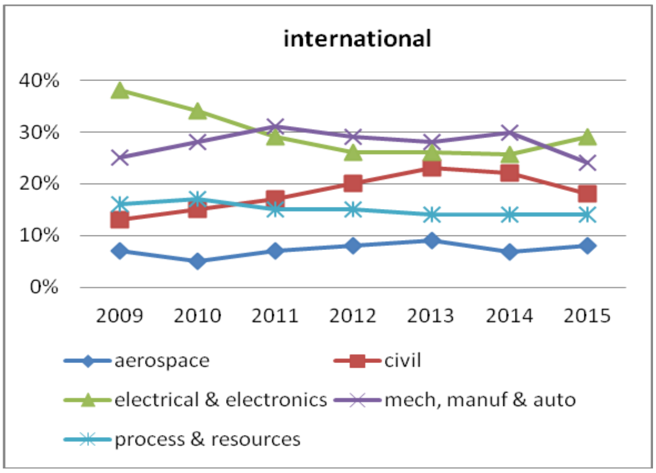
Women constitute slightly higher proportions of the graduate cohorts, as a result of their stronger academic performance.

The numbers of Indigenous students and graduates in engineering is very small. In 2015 there were only 49 Indigenous graduates recorded as having graduated from engineering with any higher education qualification.

Engineering has distinct areas of practice that are reflected by strongly differentiated degree programs. New branches, such as environmental engineering and biomedical engineering, are created from time to time, reflecting industrial, economic, technological and social needs.

The following charts show graduations in five established branches, aggregated over all undergraduate awards, for 2009-15. The relative proportions may reflect perceptions of Australian, regional and global demand for engineers.





Graduate employment rates and starting salaries have been consistently higher than those of graduates of other STEM-based areas for many years.

The 2015 Bachelor degree graduates in engineering ranked 4th on median starting salary at $62,000. Women earned $3,000 more than men. At 80%, the engineers' average full-time employment rate was 20% higher than the average for graduates from all fields of education.

The median salary for engineering Master degree graduates completing in 2015 was $100,000. This figure is probably dominated by mature individuals already employed in engineering.

Higher Degrees by Research (HDR)

The engineering faculties and schools have nearly doubled their production of HDR graduates since 2005, mostly from increasing numbers of international students:

award	2005		2010		2015	
	Dom	Int	Dom	Int	Dom	Int
PhD	452	185	474	318	603	656
Master	133	75	99	97	108	121
TOTALS	**585**	**260**	**573**	**415**	**711**	**777**

The 2015 engineering total represents 14.8% of total HDR graduations. The strong internationalisation of Australia's engineering research effort is reflected by continuing increases in higher degree commencements.

The proportion of women in both domestic and international cohorts has been around 25% for several years. This will potentially increase the proportion and numbers of women in the academic and research engineering workforce.

Research

The faculties and schools contribute to Australia's research outcomes. For engineering, external research income in four categories for 2013 and three research outcome metrics are shown in the following table. The share of the national total for each measure is also provided.

Research income (2013) / Research metric (HERDC data)	Engin'ing	% of nat total
Cat 1 Australian competitive grants	$ 153.8 M	8.9%
Cat 2 Other public sector income	$ 73.6 M	8.6%
Cat 3 Industry & other research inc.	$ 106.0 M	13.6%
Cat 4 CRC research income	$ 34.5 M	33.0%
Research commercialisation inc. (2013)	$ 4.9 M	8.4%
Patents granted (2011-13)	293.3	31.3%
Research esteem factors (2011-13)	312.9	6.3%

The importance of CRC and industry funding for engineering research is evident. Engineering produced nearly one third of the national patents granted.

The high quality of the engineering research can be deduced from national Excellence in Research Australia (ERA) data. In the 2015 ERA report, 27 universities had at least one area of engineering rated at level 4 (performance above world standing) or higher. Six institutions had five or more engineering areas rated at level 5. This level was attained in materials engineering by 14 institutions, and by 10 institutions in electrical & electronic engineering.

Australian Council of Engineering Deans Inc.

The membership of the Inc. (ACED) is a senior academic representative of each of the 35 Australian universities that provide professional engineering degrees accredited by Engineers Australia. ACED's mission is to promote and advance engineering education, research and scholarship on behalf of the Australian higher education system.

More data and trends on engineering enrolments and staffing are on the ACED website: www.aced.edu.au

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