

DOES AUSTRALIA NEED A GRADUATE SCHOOL OF ENGINEERING DESIGN AND MANUFACTURE?

INTRODUCTION

EA's National Committee on Engineering Design (NCED) has for some years been concerned about the trends in teaching engineering design in universities across Australia. It is our view that, in the competition between 'engineering science' and 'engineering', engineering is increasingly rapidly losing ground.

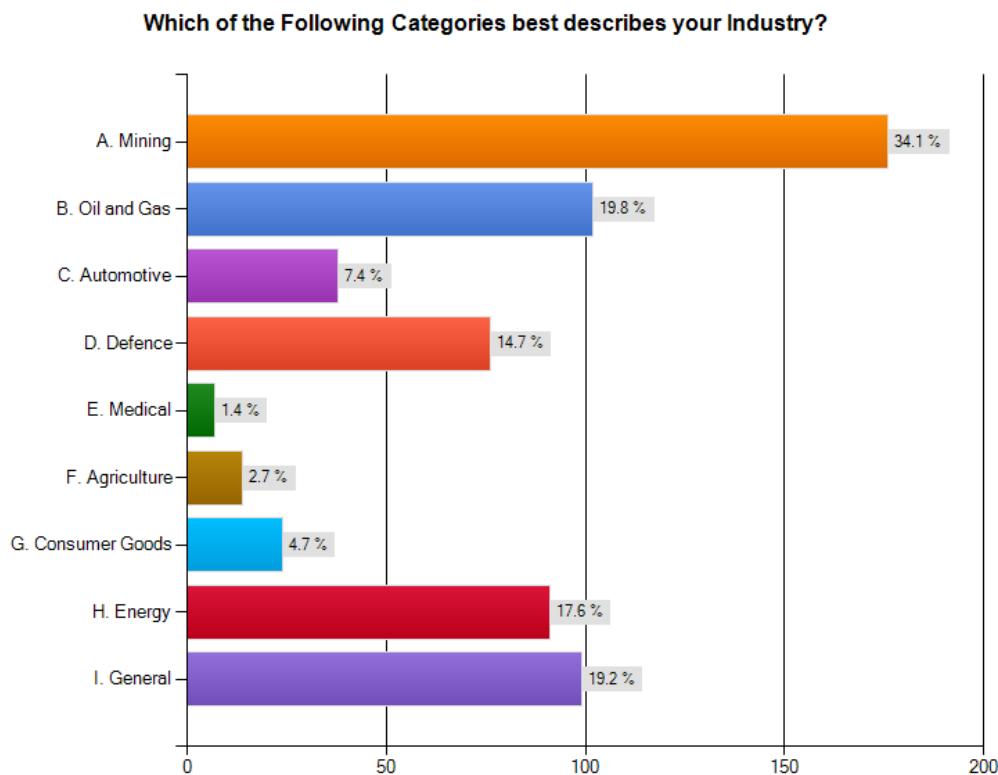
There are several reasons for this loss: difficulties arising from increasing student numbers, with the inevitable 'tail' of weaker or less motivated students; decreasing academic staff numbers; time and cost of attempting to teach the practical aspects of engineering; the retirement of the 'old brigade' who were capable of teaching practical engineering; and replacement staff chosen on the basis of their potential contribution to their school's research effort rather than their practical engineering experience.

To help counteract the move to decreasing engineering content, NCED has proposed the creation of an Australian Graduate School of Engineering Design and Manufacture. A crucial aspect is to know whether Australian industry supports the initiative strongly enough to make the concept viable. To this end, NCED worked with EA's Office of Engineering Practice to conduct a survey of members of the College of Mechanical Engineers. The survey was conducted on-line over the period December 2011 to January 2012.

The response rate was lower than expected (688 from approximately 9,500 members) but the nature of the survey questions was such that we believe a significant proportion of the responses came from members in positions of knowledge and influence within their organisation.

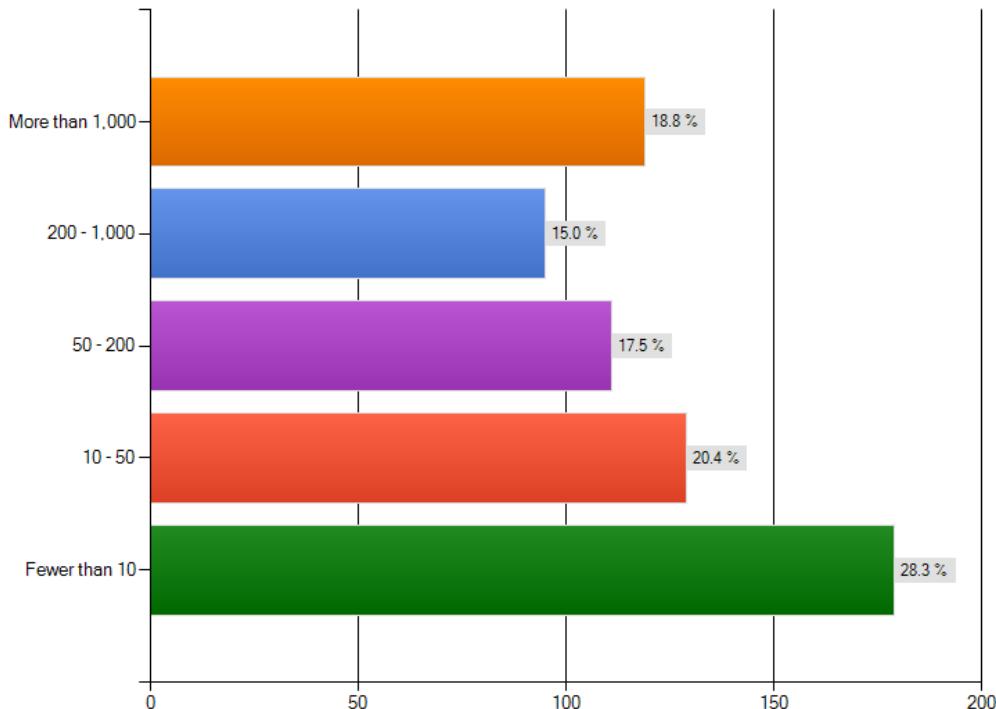
RESPONSES TO THE SURVEY

In the following charts, the caption gives a shortened version of the question asked and the abscissa is the number of responses received.



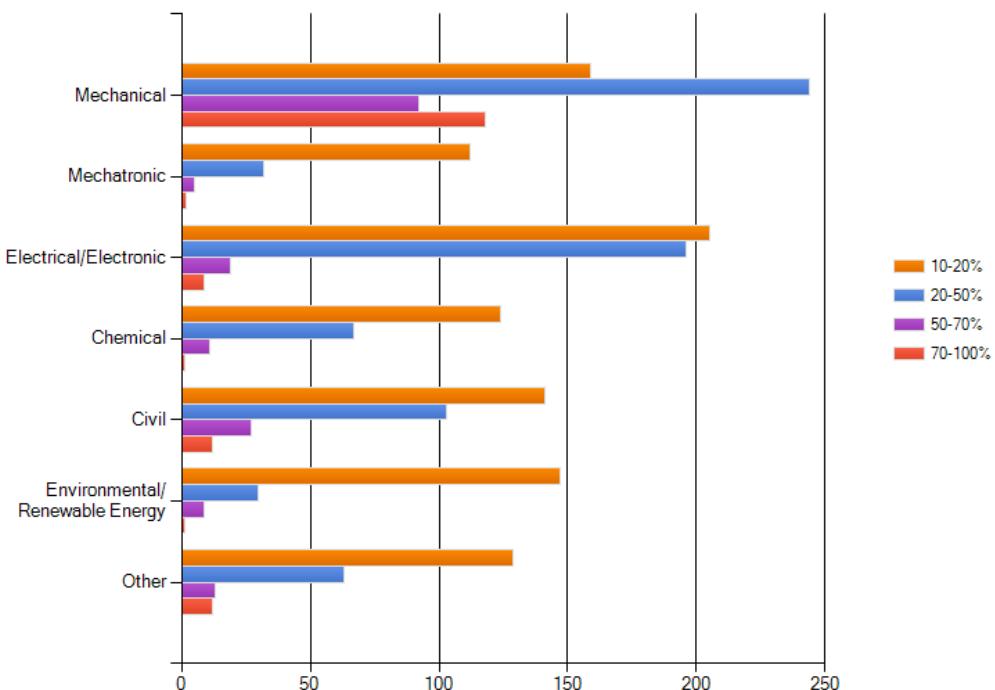
As shown in the chart above, responses to the first survey question revealed the very wide range of generalist and specialist mechanical-engineering activities in which members of the College of Mechanical Engineers were involved. Of the 516 respondents who answered this question, the largest proportion was 'mining' with 34%, followed by 'oil and gas' with 20%, 'general' with 19%, 'energy' with 17%, and 'defence' 14%. In the present climate, mining, oil and gas dominate the field with a combined 54%.

Please state the total number of Engineers that your organisation employs directly



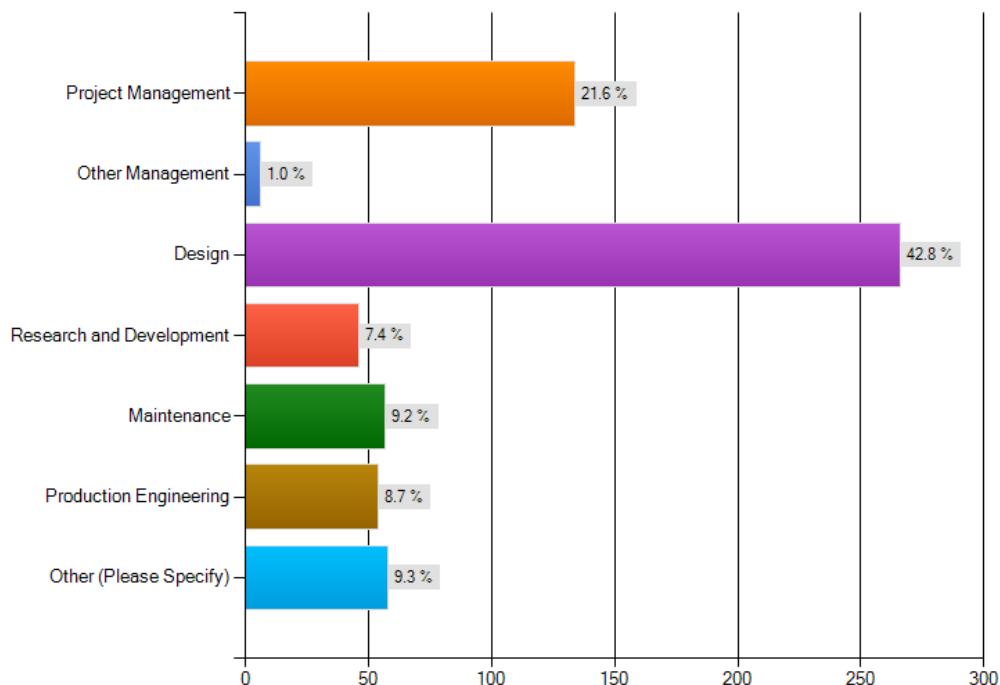
While 93% of the 679 responses confirmed that their company employed engineers, 28% employed 'fewer than 10', with 20% employing 10-50. Organisations employing 50-200, 200-1000 and 'more than 1,000' were roughly equal with response rates in the range 15-18%. An apparent anomaly was that there were 119 respondents in the range 'more than 1,000', suggesting that there were multiple responses from some of the larger organisations.

Please state the indicative percentages of your organisation's Engineers against the following fields of Engineering



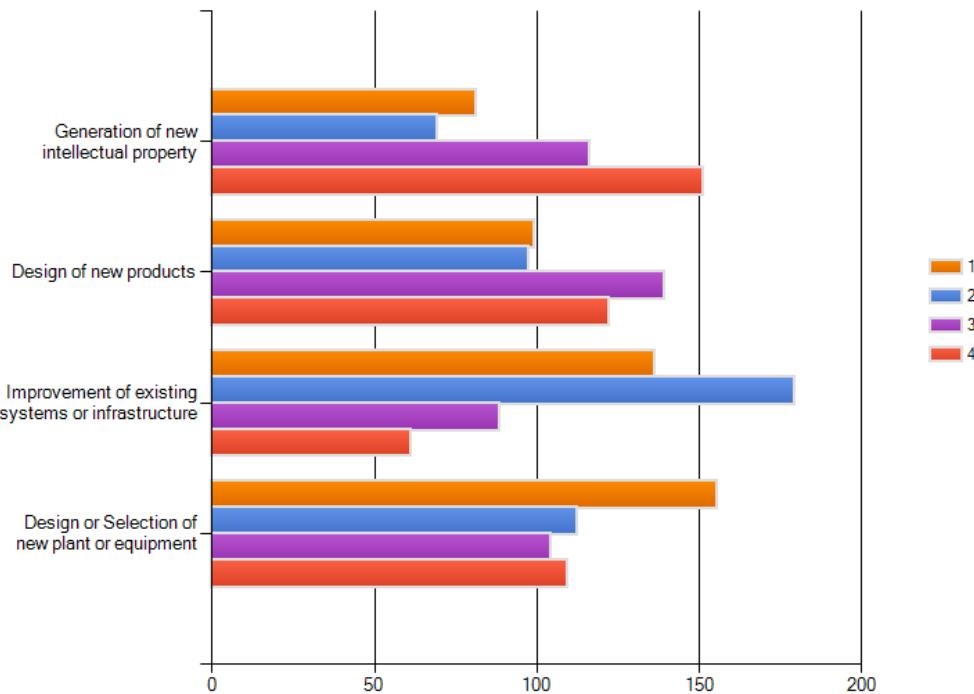
When asked for 'indicative percentages of your organisation's engineers against the following fields of engineering', responses were scattered across all categories of engineering and all percentage ranges. The largest response overall (613 of the 626 who responded) cited mechanical with the largest group in the range 20-50% of their engineering staff. Electrical/electronic drew a total of 429 responses with the largest group in the range 10-20% of their engineering staff. Civil attracted a total of 238 responses, 'other' 217 responses, chemical 203 responses, environmental/renewable energy 187 responses and mechatronic 151 responses.

Which Job Function Best Describes the function of the majority of your organisation's engineers?



Regarding job function for the majority of their engineers, 43% of the 621 responses opted for design, 22% for project management, with research and development, maintenance, production engineering and 'other' all less than 10%.

Please list in order of priority from 1 to 4 the importance of the following functions Engineers in your organisation perform.



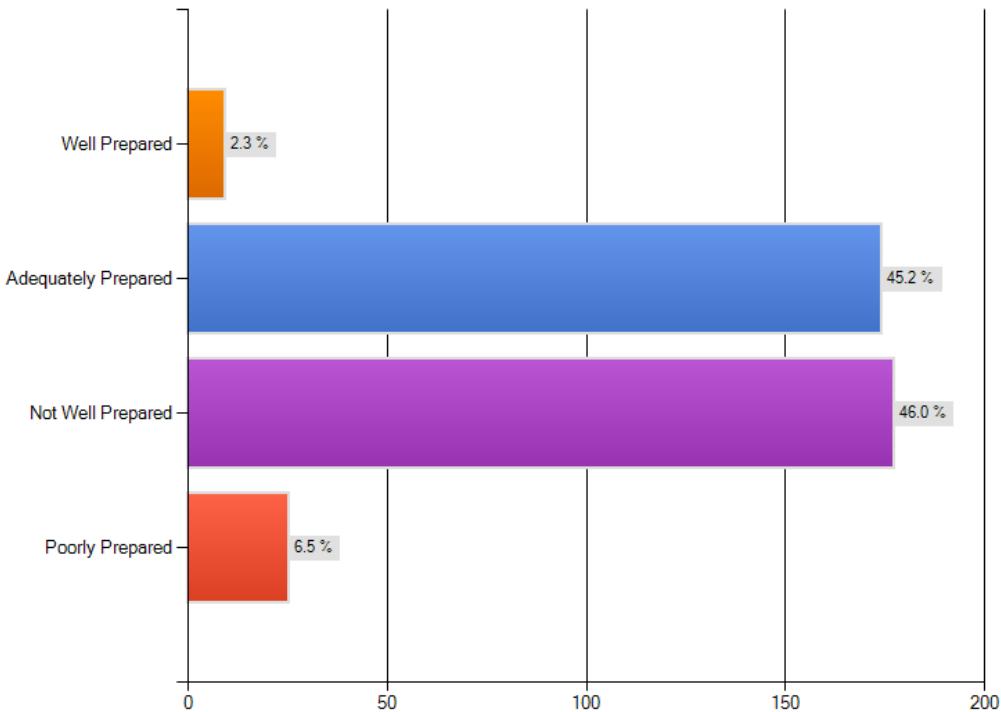
85% of the 527 respondents agreed that engineering was the primary function of engineers in their organisation.

When asked to rank the importance of various functions performed by their engineers, 'design or selection of new equipment' was the most popular first choice (155 or 30%) of the total 519 respondents, with 'improvement of existing systems or infrastructure' as preferred second choice (179 responses, 34%), 'design of new products' the most popular third choice (139 responses, 27%), and 'generation of new intellectual property' fourth choice at 151, (29%) responses. When considering which was the most popular choice overall, 'design or selection of new plant or equipment' drew 480 responses (92%), with 'generation of new intellectual property' the lowest at 417 responses (80%).

Regarding difficulty in recruiting staff with suitable skills and experience, 18% found it 'very difficult', 36% 'difficult', 42% 'moderate' and 3% 'easy'.

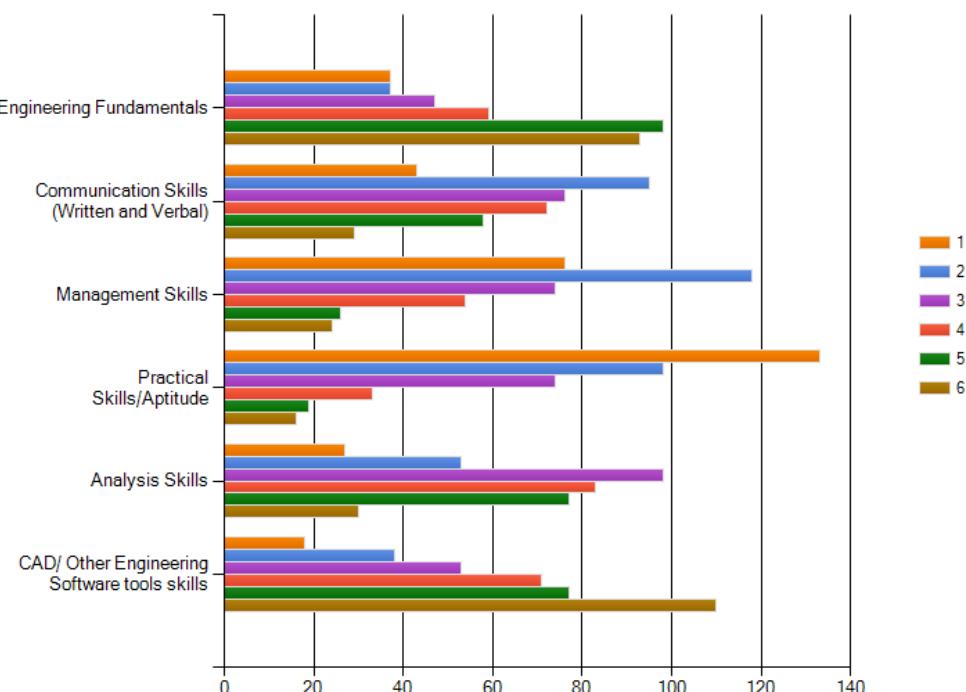
66% of respondents reported that they regularly recruited engineering graduates and, of the 66%, 43% regarded such recruitment as 'very important', and 47% as 'important'.

How "Job Ready" do you find that engineering graduates are?



Regarding job readiness, 46% found graduates 'not well prepared', 45% considered them to be 'adequately prepared', and 7% regarded them as 'poorly prepared'. Only 2% thought current graduates were 'well prepared'. In a related question, 33% of respondents considered that graduates needed 1-2 years to make a 'consistently useful contribution' to their organisation, 30% thought 6-12 months, 23% 3-6 months and 3% less than 3 months. However, 12% considered it required more than 2 years.

What areas do you find that Engineering Graduates are most lacking in? (list in order from 1 for most lacking to 6 for least lacking)

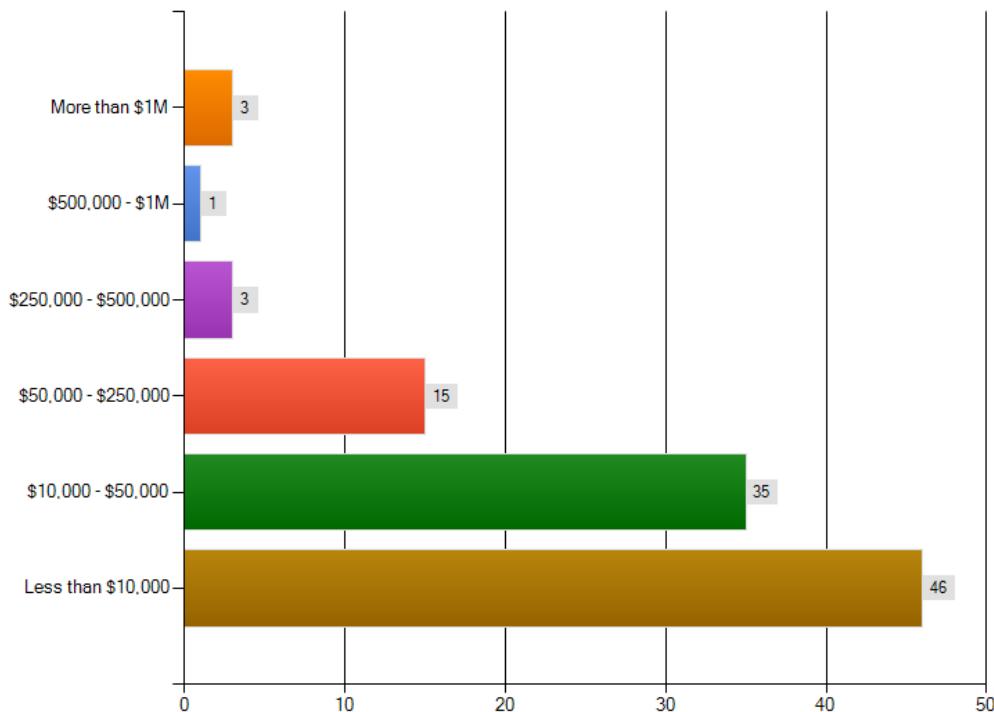


When asked to specify the areas in which graduates were most lacking, the most commonly noted weakness was 'practical skills/aptitude' at 36% of first choices. However, when considering the overall responses, 'engineering fundamentals', 'communication skills', 'management skills', practical skills/aptitude', 'analysis skills' and 'CAD/other engineering skills' each drew approximately 95% of the 388 responses.

Regarding their perceived need for design and R&D Engineers in the next 5-10 years, 45% of the 499 respondents estimated 'about the same', 40% 'will need more', 10% 'will need a lot more' and 6% 'will need fewer'.

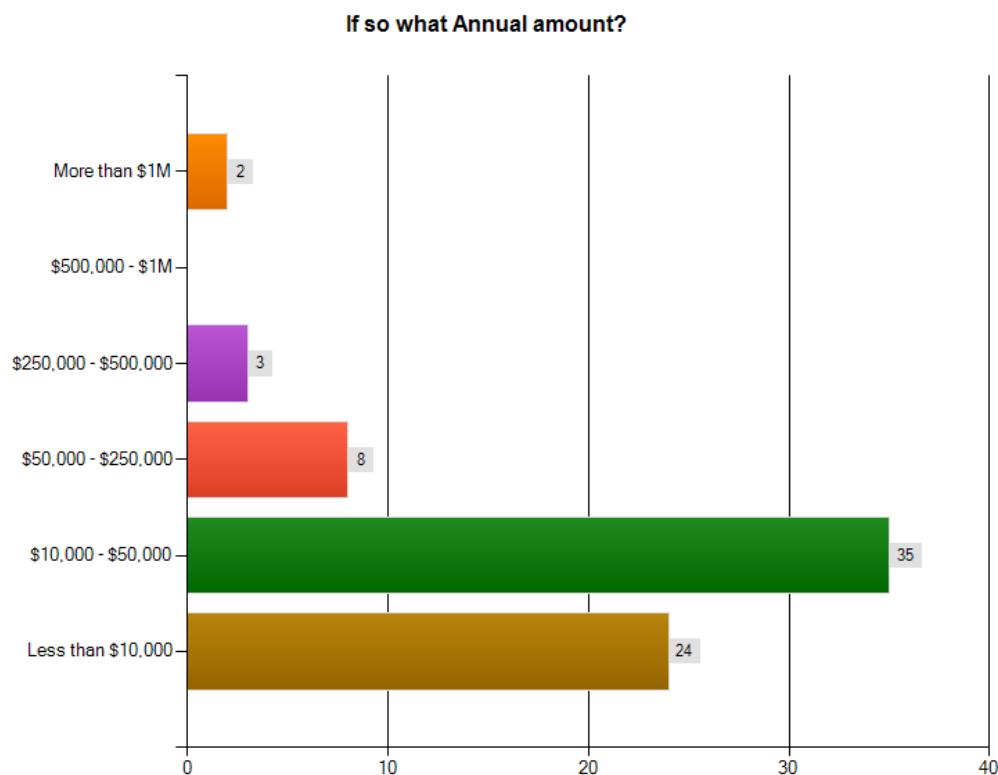
80% of the 601 respondents considered that their organisation would benefit from 'more readily available, more experienced and better qualified professional engineering designers' and 71% believed their organisation would be prepared to employ one or more professional engineering designers if they held a graduate degree in Engineering Design. Further, 45% of respondents believed their organisation's current involvement in new projects involving engineering design was restricted or prevented by lack of experienced engineering designers, and 48% thought their organisation would be more likely to undertake new projects if it employed specialist engineering designers. 35% of respondents reported that they had in mind new projects involving engineering design which their organisation would like to undertake, but felt restricted by lack of design capability, and 55% thought their organisation would be interested in a collaborative design project with the proposed graduate school.

If so, what level of support do you think your organisation might contribute?



42% of 488 respondents thought their organisation would be interested in funding either a recent graduate or a member of their existing staff to undertake a course in the proposed Graduate School and 19% (94 respondents) would consider providing one-off donations for establishment of the proposed

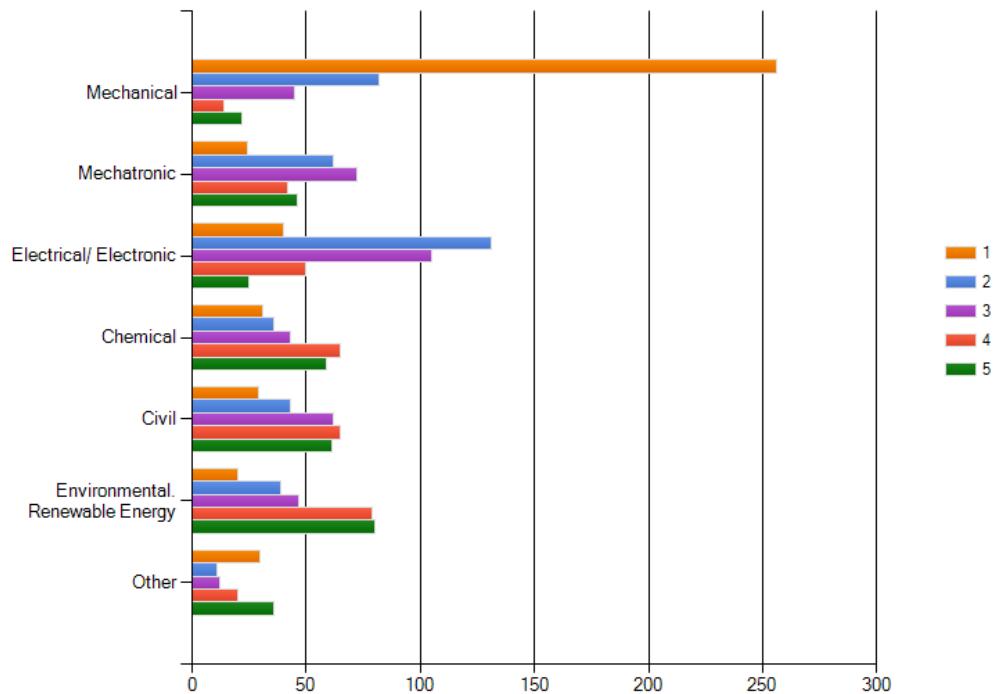
Graduate School. The chart above shows responses ranging from 'more than \$1m' (3), \$500,000 to \$1M (1), \$250,000 - \$500,000 (3), \$50,000-\$250,000 (15), \$10,000-\$50,000 (35) and 'less than \$10,000' (46).



Regarding ongoing support for running the proposed Graduate School, there were 74 positive responses, ranging from 'more than \$1m' (2) to \$250,000- \$500,000 (3), \$50,000-\$250,000 (8), \$10,000-\$50,000 (35) and 'less than \$10,000' (24).

A seat on the School's Advisory Board, priority access to recruiting graduates and public recognition were generally seen as incentives to increase the amounts offered.

Please list in order of priority (from 1 for most important to 5 for least important) the fields from which you most would like to recruit graduates from the Graduate School:



When asked for the fields from which organisations would be most likely to recruit graduates from the proposed Graduate School, mechanical engineering received by far the highest number of first choices (256 of the 461 responses), compared with 40 choices for electrical/electronic, and mechatronic, chemical, civil, environmental and 'other' receiving fewer than 31 first choices. When considering the total number of choices regardless of priority, mechanical was still the highest score with 419 responses, followed by electrical/electronic with 351, then mechatronic, chemical, civil, environmental/renewable energy with 265-234 responses, and 'other' at 109 responses.

DISCUSSION

The survey reported herein is at least a start on providing data on the opinions of Australia's mechanical engineers on the future of Australian mechanical-engineering design, as well as their confidence in the future of mechanical engineering more generally. It would have been encouraging to have received a wider response to the survey, but it is understandable that many rank and file members of the College of Mechanical Engineers saw the survey as an area in which they had little knowledge and could offer no worthwhile opinion.

The picture which has emerged from a consideration of the survey data is one which is more hopeful for the continuation of mechanical engineering in general and mechanical design in particular than might have been gained from current newspaper and political reports. This is exemplified in the question regarding organisations' need for design and R&D engineers in the next 5-10 years, in which 45% of respondents estimated 'about the same', 40% felt they 'will need more', 10% 'will need a lot more' and only 6% thought they 'will need fewer'.

The questions regarding financial support for setting up the proposed School received similarly encouraging responses, with 74 positive responses including three in the range 'more than \$1m', 15 in the range '\$50,000-\$250,000' and 46 in the range 'less than \$10,000'. Cross tabulation of results showed that the larger sums (above \$250,000-\$500,000) came almost exclusively from the 'oil and gas' industry with 'mining' and 'defence' nominating the smaller sums. It was perhaps somewhat surprising to find that two of the three nominations of 'more than \$1m' came from organisations employing 10-50 engineers, although the third came from an organisation employing 'more than 1000' engineers.

Equally encouraging were the 72 responses for 'ongoing [annual] support' including two in the range 'more than \$1m', three in the range '\$250,000-\$500,000' and 35 in the range '\$10,000-\$50,000'. Cross tabulation again revealed that, of the offers of 'more than \$1m', one came from 'oil and gas' and one from 'general', with 'mining', 'oil and gas' and 'energy' naming sums in the range '\$500,000 or less. It was heartening to find that one organisation offering 'more than \$1m' annually chose 'generation of intellectual property' as the most important function of their engineers.

It is encouraging that 80% of respondents considered their organisation would benefit from 'more readily available, more experienced and better qualified professional engineering designers', while 45% of respondents, including those offering the largest contributions, believed their organisation's current involvement in new projects involving engineering design was restricted or prevented by lack of experienced engineering designers, and 48% thought their organisation would be more likely to undertake new projects if it employed specialist engineering designers. Further, 35% of respondents reported that they had in mind new projects involving engineering design which their organisation would like to undertake, but felt restricted by lack of design capability, and 55% thought their organisation would be interested in a collaborative design project with the proposed graduate school. The positive responses included several organisations expressing willingness to contribute large sums both to set up the proposed School and for its ongoing running costs. We conclude that a significant proportion of the Australian mechanical industry

retains at least some vision for an ongoing industry turning out pioneering engineering design.

It is significant that, when asked to specify the areas in which graduates were most lacking, the most commonly noted weakness was 'practical skills/aptitude' at 34%. This is considered an indictment on current trends in teaching engineering design in universities across Australia, where engineering is giving ground to engineering science. Whilst the proposed Graduate School cannot be expected to reverse the trend across the student cohort, we believe that it can make a huge difference to a select group – Australia's future pioneering designers – who graduate from the School, and may serve to gradually increase awareness of the importance of practical engineering in engineering schools across Australia.

Some idea of the difficulty experienced in recruiting engineers with suitable skills and experience is revealed in that the two organisations offering 'more than \$1m' annually rated their difficulty as 'moderate' and 'difficult' respectively. The same two organisations rated 'graduate recruitment' as 'very important' and 'important' respectively and rated graduates as 'adequately prepared' and 'not well prepared' respectively, citing a need for '6-12 months' training and 'more than 2 years' respectively. Both organisations, as well as the 7 others offering substantial contributions, expected to 'need more' designers over the next 5-10 years, expected their organisations would benefit from the availability of better designers, would be prepared to employ such designers, would be more likely to undertake new projects, had in mind new projects currently restricted by lack of design capability and would be interested in funding a staff member to undertake a graduate course in the proposed School. We believe there is a strong element here of a willingness to "put your money where your mouth is".

A representative selection of the textual responses to the survey questions is attached to this document. The list is generally self explanatory, showing diversity of opinion on the merits of the proposed graduate school, varying from "it's too late now for Australian design and manufacture" to heartening glimpses of a vision for a new and rejuvenated industry. One of the recurring themes was the thought that more academic study was unlikely to change the skills of fresh graduates. However, the preamble to the survey attempted to make it clear that the proposed school was to be above all an opportunity for students with some innate design flair to 'catch' engineering design from mentors already 'infected', focussing heavily on developing such skills as creating concepts, 'on-the-run' freehand sketching, relationships between design and manufacture and building simple models, all directed and driven by mentors/instructors with actual and ongoing industry experience. From the balance of the comments, as from the support which came from the direct answers to the questions, we believe there is encouragement to press on to the next stage of implementing the proposed school.

CONCLUSIONS

We conclude that the concept of a Graduate School of Engineering Design and Manufacture has industry support and is worth further investigation. From the responses and a review of the appended comments, the vision of an Australian

industry producing world-competitive design remains alive, although struggling in the present industry climate.

Much remains to be done if the proposed Graduate School is to become a reality. It would be helpful to have the active support of an industry body, and the NCED encourages Engineers Australia to integrate the proposal into their priorities for submission to government bodies.

At this stage, it would be interesting to hear the views of some of Australia's universities.

Alex Churches

Chair, NCED

13 April 2012

***The National Committee on Engineering Design
would be pleased to receive comments on the
findings of this survey and is particularly keen to
hear from those organisations which have
indicated a willingness to contribute to funding
the proposed school. Please reply to
alexchurches@optusnet.com.au.***

ATTACHMENT

COMMENTS ON QUESTIONS

Not all questions elicited comments. The following quotations have been selected in an attempt to give a balanced view of the opinions of respondents. Most comments came in response to the question on perceived lack of graduate skills.

U of xxx would be interested - new undergraduate degree in design would be an excellent pathway into this programme, students would do a double major in design and engineering science (mechanical).

Some current graduates are good - the majority are awful. Very few have any idea how to use a CAD system or write a document. Most know a little bit about some very specialised areas of study – e g thermodynamics or FEA, but have no idea how to apply them in the real world.

Hands on in laboratory techniques, knowledge of design processes.

Understanding 'design for manufacture'.

Design and development process and appreciation of quality and risk are not understood at all.

Got to be able to create/develop/demonstrate solutions via hand sketching while in dialogue with a client in real time.

We currently send a small, but regular group of engineers overseas each year to graduate schools as there is no opportunity in Australia to study at this level.

The organisation would benefit from Engineers with improved design skills but retention could be an issue as our industry tends to be very risk averse to new indigenous design and Australian Government/Business/Industry does not want to invest in developing capability (ie learning/potentially making mistakes) when it is readily available from overseas suppliers. When the majority of engineering businesses in Australia have parent companies based internationally, there is less scope for development in Australia as the parent company retains the intellectual property and wants to keep the work in their home country. If designers want to work at the leading edge of design, they tend to travel to those other countries where that design is taking place.

We run a short engineering quiz of basic engineering concepts (e g moment of inertia, max moment in a simply supported or cantilevered beam, typical construction methods for aircraft). Most graduates cannot answer 50% correctly.

There appears to be potential for extending the continuing education field for professional mechanical engineers. I am now in the twilight of my career but have been a strong advocate of continuing professional development activities that achieve recognition. Formalised post graduate courses not necessarily aimed at a Masters or Doctoral program have a place in the continuing education space. Delivery by a School that focuses on that market segment should lead to good quality and high appeal.

If not directly employed it would enhance local capability to be accessed when needed for resolution of specific problems normally needing overseas resources.

There is a need for optimal design taking into account energy use and generation and cost effectiveness together with overall functionality and environmental sensitivities.

I don't believe that the proposed Graduate School will succeed. Graduates themselves seem to have little insight that such a place may help them, and I believe it is aiming at far too specific a part of the market. What this country needs is grass roots interest in manufacturing and design, not just amongst practising mechanical engineers, but all engineers and the general public at large. Instead of a graduate school in mechanical design, Australia needs places where people can go to prototype new ideas, perhaps under the guidance of "the engineer or designer in residence". (*Materials handling*)

Designers come from TAFE, and engineers are not allowed to do CAD due to union pressures. Drafting is dead in the rest of the world, but not in Australia where it is protected. Drafting poses a significant bottleneck in the engineering delivery process.

The school could provide a wider design exposure allowing designers to explore more options and think more laterally than at present. However we have found that deviating too much from existing designs has lead to unexpected problems and significant cost and time overruns. Perhaps higher trained designers may be able to avoid some of these issues.

Important to provide extra design skills for synthesis of innovative creativity.

The ideal post graduation learning is from experienced engineers. The low level of practical engineering passed on to graduate engineers does not provide any confidence further academic training would improve the situation.

Best they just get into industry and build up their skills and confidence. We don't expect anyone entering the field to be fully up to speed with what we do and another level of engineering education would be a poor substitute to the mentoring provided.

Unfortunately, little of the 'mechanical' equipment we design FOR is manufactured in Australia anyway.

Would be best if there was a period of work 1st as more education straight away is lost. Practical skills & trades are very highly valued as these seem to give a huge increase in the ability of engineers to apply practical solutions & to communicate with the people who build equipment.

The organization may benefit from better qualified design engineers if some of them were senior managers. This is unlikely to happen in this organization.

I have 20 yrs experience of academic depts in the field of production and particularly terotechnology and have worked with and taught PG design students . I am a retd prof living in Perth. Pse contact me if you think I can be of use in this project. (*Contact details provided*).

A better prepared graduate program that is industry standard would be better. Especially for those companies that are not big enough for a full scheme.

Practical experience is an essential ingredient for state of the art design or even just good design as is a thorough knowledge of the resources that can be used to manufacture whether a one off, limited production or mass production.

Possibly. Provided the Graduate school is not a front for more Climate Change fraud.

I am not sure what the benefits are of the Graduate School compared to a more diverse University Degree. The cost of completing the course could be too high or the subjects could be undergraduate ones just offered at post graduate level, thus, the debt to the student is too high.

But depends on the focus. We are not looking for manufacturing based design. Consultation with engineering consultancies on what they are looking for would be of benefit, and in 5-10 years these grads will compete directly with a developed off shore design resource base.

Engineering graduates generally have little to no practical skills and these need to be developed. For design engineers the best generally are those that have undertaken an apprenticeship or some lengthy work experience

Will not be employed by us. Having said that the engineering function in design houses used by us is generally considered high quality. Innovation would be the main area for improvement.

In small numbers the improved skills would be beneficial. However, we may more readily gain from those skills being developed within our industry suppliers.

In all of my places of employment the organisations would have benefited by a higher standard of design trained engineers.

I agree completely with the introductory paragraphs to this survey. Such a proposal will not only be of immediate benefit to Australia's current mining boom, but, more relevantly, will be the necessary preparation for the time when resource mining declines, and Australia's income may well return to manufacturing. The proposal to allow focus on high-tech, specialised manufacturing is an excellent way to start.

As I don't have employees, the answer is no. However, I have had over 50 years engineering experience in automotive, military, and energy fields, involving design, development, testing and creation of intellectual property. I see the proposed role of a proposed Graduate School as something that could be of very large benefit to Australia, both domestically and in gaining overseas business.

There are a very large range of disciplines and don't think the proposed graduate school can be focussed broadly enough, and also narrowly enough to make a difference.

My opinion is that design work rarely needs beyond year 3 skills of a BE course. What is important is a love for design and a willingness to add practical skills to solid technical understanding.

We are finding that our products have been manufactured to old designs which are no longer valid with modern manufacturing methods. There is little

experience to call upon for basic manufacturing such as casting and forging of complex parts. Such a Design course could fill this gap.

People need real experience. Schools just cannot provide it.

Engineering training has lost sight of design and setting good foundations of understanding fundamentals. The profession has become so geared to consulting that we have a generation of younger engineers who are practically useless for design or product development. Way more practical hands on work experience is required.

I think the current Engineering graduates are not provided with the practical engineering exposure. Many lack understanding of fundamental mathematical and engineering functions. It appears they are taught to seek everything as granted which makes them unable to think beyond

As [our] work is very specific it would not be expected that a generic course would make a significant difference to inhouse development/training required.

It would be preferable to bring undergraduate courses up to scratch, instead of compensating for the poor quality by adding another course/qualification.

A lack of skilled productive design engineers has been a constraint on our growth since 2004. This is now at a point where we are considering to help our competitors to enter the Australian market so that we can assist the market to become more ideal, that is, a market with lots of buyers and lots of sellers. Sounds odd. But we are unable to make use of our rare skills because we just cannot get enough engineers to fully utilise them. (*Mining industry*)

It will have Professional Engineers taking ownership of their group work and helps in productivity of the group.