Australian engineering academe: a snapshot of demographics and attitudes

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***Abstract*:**

This paper provides a preliminary review of survey data gathered from engineering academics across Australia during late 2010 and into early 2011. Previously, little has been done to gather and interpret the demographics and attitudes of engineering staff in higher education institutions. The survey was done as part of several Australian Learning & Teaching Council (ALTC) projects addressing challenges in enhancing engineering education practice.

This "snap-shot" of the survey data provides some interesting insights into the current status of engineering higher education professionals. It should provide a basis for on-going considerations around challenges, opportunities and barriers related to quality and change management in engineering education. The paper outlines some key areas in engineering academe and educational practice from over 600 respondents covering all major university groupings such as the Group of Eight (Go8), Australian Technological Network (ATN), Innovating Research Universities (IRU) and non-aligned institutions, and over 15 engineering sub-disciplines.

Introduction

No serious attempt has been made to obtain wide ranging information and views from Australian engineering academic staff, despite a plethora of engineering student surveys. Apart from regular survey data published by Engineers Australia, no serious attempt has been made to understand the broad context and attitudes of academic personnel in Australian engineering schools and departments. Some confidential information is regularly gathered as part of accreditation processes carried out by Engineers Australia and also the Institution of Chemical Engineers. However, this information is very limited and remains part of the confidential accreditation report presented to participating engineering schools.

In response to this lack of open data, two of the authors (IC, RH) devised a survey instrument that sought to establish demographic information related to gender, discipline area, age, academic and industrial experience as well as gleaning attitudes to a wide range of work-related issues. These issues sought to address the teaching and research nexus, attitudes to teaching and learning, pedagogic practice, understanding of professional engineering practice outside the higher education sector, and also attitudes to rewards and motivation. The survey was developed with review input from key people involved with the Australian Council of Engineering Deans (ACED), Australian Association for Engineering Education (AAEE) and Engineers Australia (EA). There were 38 individual areas surveyed, with opportunity for recording individual written comments and ideas.

Over the second half of 2010 and into 2011, through the respective deans, academic staff were encouraged to complete the on-line survey. From this period 613 responses were received, amounting to approximately 82,000 data values. The following sections give a 'snap-shot' of the key outcomes, with some commentary on the significance for the sector in terms of challenges, opportunities and barriers for beneficial educational change. Much remains to be done in understanding some of the deeper cross-correlations in the data set, as well as the syntactical analysis of the many written comments that were submitted by respondents.

The following sections highlight aspects of the 3 main areas in the survey, namely, demographics and academic roles; experience in and understanding of industrial and commercial environments; attitudes to teaching and learning.

Demographics and academic roles

One of the intentions of the survey was to obtain a snap-shot of who is working in the engineering higher education (HE) sector. Responses to a series of questions around gender, age, qualifications, sub-discipline area, location, experience and roles were gathered. This indicated a number of interesting outcomes that re summarised in Table 1.

Table 1: Summary outcomes for some demographics and academic roles

Item	Outcome	Observations
Gender	17.2% women, 82.8% men	This seems almost in-line with current female participation rates in engineering degree programs
Age profile	53% of women are under the age of 40, compared to 40% for men. Above the age of 50, men dominate with 36.4% compared to 15.3% of women.	Of the disciplines examined, the youngest disciplines (% <40yrs) were represented by chemical, aeronautical, bioengineering and environmental. Older age distributions were seen in civil, electronic and mining. Electrical and mechanical were mid-range.
Language	36% of respondents had English as a second language.	There was little difference between men and women in regard to language.
Fractional appointments	13.6% of men and 22.4% of women had fractional appointments.	Of these, 48% of men and 29% of women had fractional appointments of 2 days or less.
Time management	Over 6 areas of personal activity, those who responded to individual areas had averaged values of: 45% on research, 35% on teaching, 21% on administration, 9% on consulting and 9% on service.	Essentially similar responses for men and women with a higher average engagement in consulting for women than men.
Main drivers for priorities	These were in rank order (high to low): personal interests; student satisfaction; institutional priorities; other non-specified; external drivers such as the ERA*.	It is interesting to see the ERA ranked lowest, given the priority commitment to research.

*Excellence in Research Australia assessment framework

Much of this basic data is not particularly surprising. Some of it could be predicted from anecdotal evidence. However, there are interesting differences across disciplines with regard to staffing and age profiles and what drives respondents in setting their priorities. One promising result is the reported percentage of women academics in engineering. The figures, whilst revealing a positive trend upwards from previously reported numbers of 8% in 1996, and 14% in 2001, give cause for consideration of strategies for the increase and retention of women in engineering HE (King, 2008).

Industrial and commercial experience and understanding

Industrial or commercial experience

The survey asked respondents to identify whether they had industrial or commercial experience outside the HE sector and how long ago did that experience take place. This was for up to 3 past professional positions. The response rate was 77.5%, 36.2% and 17.2% for the 3 professional job positions. Figure 1 shows the responses for the most recent professional position outside the HE sector, giving a selection of the responses from 1 to 20 years of experience, with relative numbers of respondents indicated by the bubble sizes.

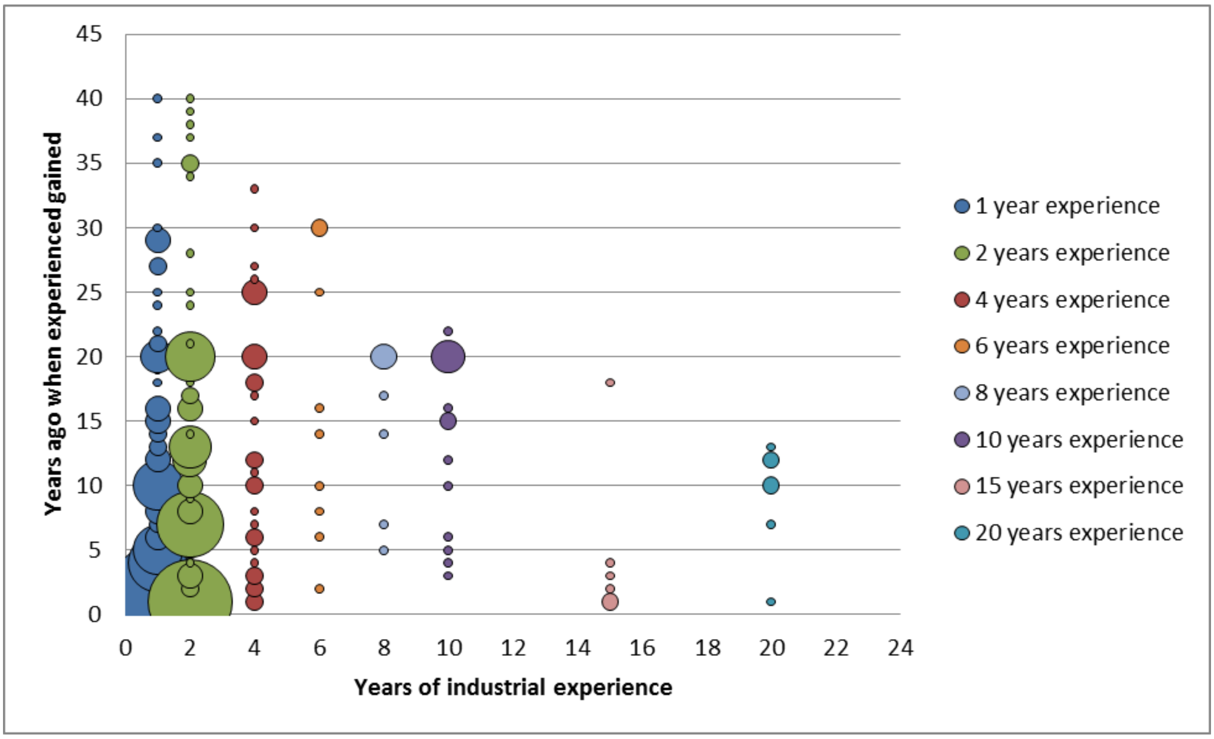

Figure 1 Count of those with industry experience and years worked

There are a number of issues that this data raises. One is the relative lack of engineering academics with professional experience beyond 4 years. The other issue is the currency of that professional experience, which in most cases was gained many years prior to entry into the HE sector. The knowledge and skills in such areas as design may be quite dated. It is also clear that many had short-term research experience before coming into the HE sector, as seen in Figure 2.

In the context of teaching and learning (T&L) developments and the implications on T&L strategies for the future, there will be major challenges around getting new staff with relevant and contemporary professional engineering experience or providing this through other mechanisms. This will be crucial in creating curricula that effectively bring together theory and practice, along with developing and enhancing critical thinking skills.

Roles played outside HE sector

Figure 2 shows where in the product-process life cycle current academics have worked, who previously had work experience outside HE. Clearly this is dominated by R&D, followed by design and operations. In many cases those experiences, particularly around design and operations would not be current.

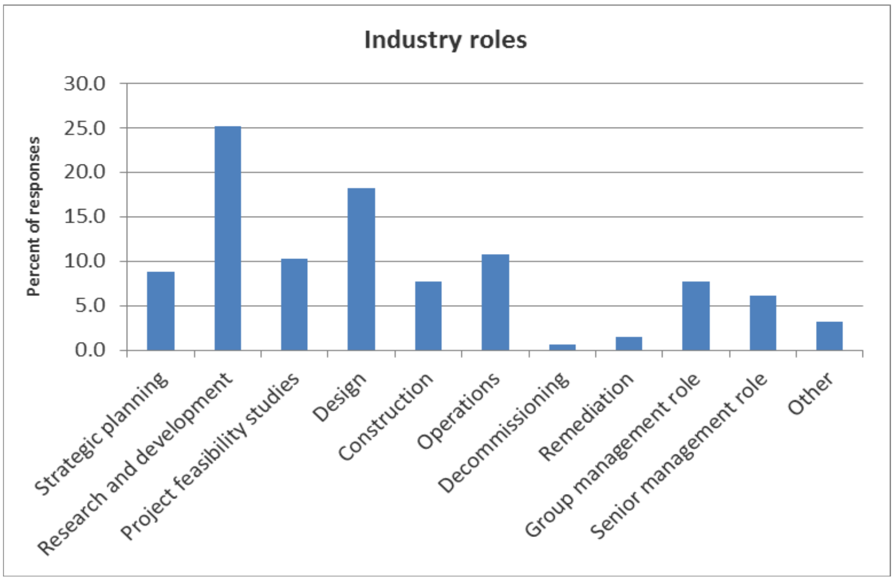

Figure 2 Life cycle roles played outside the higher education sector

The trends here are understandable given that research clearly plays a very important role in HE institutions. With respect to teaching and learning issues the results give a sense of urgency to Recommendation 3: "Implementing best-practice engineering education" within the recent review of engineering education. This overall lack of experience in deep practice knowledge casts doubt on our ability to define and operate curricula more strongly in areas of authentic engineering problem solving, engineering application and practice, with themes of design, the engineering life-cycle, complex systems, and multi-disciplinarity (King 2008).

Higher education teaching and learning issues

In this section we highlight some of the more interesting responses around factors influencing approaches to teaching and learning as well as attitudes to teaching and learning.

Issues informing teaching and learning role

Respondents were asked about the importance they place on a range of factors that inform their approaches to teaching and learning. Some were related to university and curriculum inputs, others to outputs and learning processes. Table 2 shows some selected results.

Table 2 Importance of issues that inform approaches to your teaching role

Item	Description	Rating (% very important + important)
1	Development and exercising critical thinking skills in students	95
2	Understanding the capabilities of students entering engineering programs	91
3	The need to balance theory and practice in the engineering curriculum	90
4	Understanding and developing the graduate attributes needed when students leave the HE sector	88
5	The role of modelling, simulation and visualisation	86
6	Situating learning in real-world contexts	83

This shows 3 key issues of developing and exercising critical thinking skills; balancing theory and practice in curriculum and understanding the capabilities of incoming students. Other high ranking issues were: understanding and developing graduate attributes, and situating learning in real-world contexts. These higher ranking issues encompass both the inputs, outputs and pedagogic processes within curriculum and point to the importance of curriculum/course design to deliver skilled engineering graduates.

The lowest ranking issues involved:

- Understanding the character of Gen-Y students (53%)
- Familiarity with engineering education literature (58%)
- The need for subject and curriculum renewal (69%)

Although these are not ranked as high as those in Table 2, there are some interesting contrasts due to the potential implications that flow from the higher ranked items. Although there is moderate importance placed on subject and curriculum change to facilitate improved learning outcomes which bodes well for continued quality improvement of the curriculum, there appears to be little or no sense of urgency in understanding the student cohort. This lack of interest in the inputs to what is essentially a system of learning runs counter to the proposition that all engineering academics view their teaching and learning as a systems engineering problem. The need to design effective curriculum that matches "the background and learning needs of individual students" within the given resource constraints is critical in light of government and institutional moves towards outcomes and standards based funding of universities (King, 2008).

Although ranked 4th on the list, the issue of understanding and developing the graduate attributes needed when students leave the HE sector still reflects a strong positive belief. This correlates well with an earlier nation-wide ALTC funded project entitled The B Factor: understanding academic staff beliefs about graduate attributes (de la Harpe, 2009). In this study, although academics expressed a positive belief about the value of, and willingness to assess graduate attributes, they were not confident of assessing them. This is of particular concern given the evidence from an ALTC funded forum of over 100 industry and academic participants which found that the top 3 competencies that industry expected from graduates were (Goldsmith et al, 2011):

1. Personal skills and attitudes/professional attitudes
2. Communication: ability to communicate effectively
3. Designing: proficiency in engineering design

These results when taken in conjunction with the high number of engineering academics with English as a second language and the overall lack of recent and relevant industry experience raises serious concerns. An ability to improve design and practice competencies and consolidation of situationally authentic pedagogies such as Project Based Learning is strongly contingent on developing effective "language-centric" assessment tools. Assessment tools such as written reports, individual student reflections, peer- and self-assessment, design logbooks and learning portfolios are also important means of evaluating and improving curriculum design changes (Sheppard, 2010, Dym, 1994). Developing and implementing best practice learning and assessment to ensure acceptable levels of basic business level communication skills let alone making inroads into improving engineering design and creativity will continue to be a challenge.

Attitudes to teaching

To gain some insight into what attitudes are held by current engineering academics, an indication of approaches or dispositions towards teaching were generated via a series of questions drawn from the Attitudes to Teaching Inventory (Trigwell & Prosser 2004). We recognise that this instrument has its limitations. The ATI poses 16 questions, 8 of which are indicators of tendencies towards conceptual change/student focussed (CCSF) learning. The other 8 questions indicate tendencies towards information transmission/ teacher focussed learning (ITTF) approaches. Table 3 gives results for a selection of the ATI statements which give the strength of agreement with those statements. The average is based on the scale of 1 to 5 where 1=only rarely; 2=sometimes; 3=about half the time; 4=frequently; 5=almost always.

Table 3 Selected results from the ATI, showing averaged response values

Item	Statement	Response Average
1	In my interactions with students, I try to develop a conversation with them about the topics we are studying	3.96
2	I feel that assessment in subjects should be an opportunity for students to reveal their changed conceptual understanding of the subject	3.64
3	I feel it is important that the subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items	3.40
4	I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop	3.40
5	In teaching, I use difficult or undefined examples to provoke debate	2.68
6	In subjects, I concentrate on covering the information that might be available from a good textbook	2.53
7	I think an important reason for running teaching sessions in a subject is to give students a good set of notes	2.36
8	In a subject, I only provide the students with the information they will need to pass the formal assessments	1.56

Within Table 3 we have shown the top 4 and bottom 4 rated responses. Of the top 4 statements in Table 3, items 1, 3 and 4 are related to the CCSF indicators, whilst item 2 is typically in the ITTF set. For the bottom 4 items, the ITTF indicators are given by items 6, 7 and 8, with item 5 being from the CSSF indicators. There is an indication from these results that a significant proportion of engineering staff have a preference towards a CCSF approach, with some suggestion that women have the stronger commitment to student focussed learning. This does reflect some degree of uncertainty in comparison to less positive results presented in (Goldsmith et al, 2010). In this study, a similar survey was implemented but triangulated against in-depth interviews of fewer (16) academics and an examination of course materials. Taken together however, the results suggest that while academics believe in a CSSF approach, they appear to be less confident in translating this into practice.

Assistance in the teaching role

When asked about what would be beneficial for the teaching role, respondents identified two prime areas of assistance. These were ‘face-to-face opportunities to informally discuss teaching and learning issues with colleagues’ (77%: desired + highly desirable), and ‘ability to access high quality, validated teaching and learning materials via respected repositories’ (70%: desired + highly desirable). Other highly ranked areas related to ‘personal assistance in developing courses … and teaching and learning materials’. Lower ranking issues related to ‘easy access to HE educational literature …’, and ‘staff development to enhance verbal and visual communication skills’.

It is interesting that informal T&L discussion rank very highly, possibly suggesting that these opportunities may not be present within the life of many schools or departments.

Attitudes to recognition in teaching and learning

The survey considered the importance of recognition and reward in teaching and learning, from a personal viewpoint and the respondents’ perception of how the institution regards T&L performance in promotion. The personal viewpoint showed 75% considered recognition and reward as ‘important’ or ‘very important’. The perception about how the institution regards T&L in reward (promotion) was

48%. There is still a credibility gap in the minds of many which has the potential to dampen willingness for T&L change.

Conclusions and future work

This paper is a snap-shot of a large data set generated by the ALTC Fellowship and Discipline Scholar work of two of the authors. Much can be done in extracting more subtle information from the survey. However, there are interesting pointers in the data for addressing areas of educational enhancement and change which have informed the development of strategic change models presented in a companion paper (Reidsema, 2011).

Of prime importance is the expansion and retention of women in HE engineering roles; the strengthening of academics with relevant and timely industry experience; informing and promoting the nexus of theory and practice coupled with real-world contexts for problems and projects; addressing assistance mechanisms to enhance the teaching role which include increased opportunities for informal collegial discussions, access to high quality T&L resources and professional educational assistance in preparing T&L resources.

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