Beyond Exam Results: 3 years of student admission interviews for undergraduate engineering

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Abstract: *The University of New South Wales introduced interviews for undergraduate admissions in 2006. This was one of several initiatives to broaden engineering study and move from focusing on traditional academic knowledge towards building ability in professional engineering design problem solving. We analysed interview and 1st year academic results for 600 FEAS applicants who subsequently became undergraduate engineering students at the University. The analyses show that that student success overall is still strongly related to theoretical skills, despite curriculum change initiatives. Other studies suggest a potential explanation: established engineering academic value systems are hard to shift. Both the interviews and undergraduate coursework assessment are conducted mainly by academic researchers who have themselves successfully come through a traditional engineering education. The results of this study have not only suggested how to improve the interview processes, but have also provided quantitative evidence of the systemic mechanisms that sustain established learning and teaching practices.*

Context

In Australia as elsewhere there have been calls for changes in the education of professional engineers. The University of New South Wales (UNSW) has Australia's largest Faculty of Engineering and is involved in national projects on engineering curriculum development. Since 2006, the Faculty has been introducing more design project work into undergraduate programs and has also added optional interviews to the student admission process. The Faculty of Engineering Admission Scheme (FEAS) aims to identify students who are both able and motivated, but may not meet the required academic admission criteria based on their high school exam results.

The student experience, and student progression through degree programs, depends heavily on our current disciplinary academic communities. The majority of our teaching is done by lecturers and tutors who have themselves successfully come through a more traditional academic engineering education than the one we are now aiming to offer. So the profile of the academic staff has been relatively unchanged.

The research reported here began as an evaluation of the FEAS interview scheme, to ascertain how well the interview scores predict student success in 1st year study. The FEAS process involves structured behavioural interviews in which two academics interview each applicant. Interviewers are given training and guidance on how to conduct the interviews, what kinds of questions to ask, and how to assign scores to each applicant on a range of criteria. The interview score is a normalised total of both interviewers' scores for the following criteria:

- academic achievement potential (A score)
- motivation and interest (M score)
- interpersonal communication skills (C score)
- personal qualities (P score)
- overall potential (O score).

The two interviewers record their individual Judgements as a mark on a fuzzy rating scale from 1 to 5, 'very poor' to 'very good', and someone else converts these to a numerical score afterwards.

Research questions

We now have three years of data from over 600 students who took part in FEAS interviews and subsequently entered one of our BE degree programs. The research reported here sought to analyse these data to answer the following questions:

1. Is the interview scoring process sufficiently consistent across different interviewers to be reliable?
2. Does the FEAS interview score really measure something different from the abilities reflected in the student's high school exam results?
3. How do the FEAS interview and school exam scores each correlate with student progression in the early years of study?
4. Is there evidence of a persistent bias in favour of traditional academic assumptions about how engineering knowledge and skill are best acquired?

Most UNSW Engineering graduates become practising engineers, not researchers. Research in the US shows that there is a disjunction between the graduate capabilities sought for professional practice in engineering and the learning preferences and teaching practices of engineering academics. Our traditional engineering educational systems value and reward theory-led learning styles, yet the profession requires, and attracts, people who have experiential and pragmatic learning preferences (Bernold, Spurlin, and Anson 2007).

The research questions therefore also seek, more broadly, to find out how well the Faculty's academic community is responding to the recognised need for curriculum change, and to identify underlying processes that might be managed more effectively.

Theoretical framework

The research questions, and Research Question 4 in particular, recognises systemic interdependency within disciplinary learning and teaching. Different disciplines have their own teaching and learning regimes (Trowler and Cooper 2002). Applying systems thinking to research implies that:

- A disciplinary learning and teaching community is a complex adaptive system, in which theoretical representations, such as the identification of categories of agents and their respective characteristics, are necessarily simplified maps of a complex reality (Allen 2001).
- The simplifications within a theoretical model also include the system boundary that defines the scope of the problem, which can be contested and negotiated (Checkland and Poulter 2006).
- Simplifications chosen for the purposes of the research will influence both the research methods and the outcomes, and should therefore be made explicit so that they can be reviewed.

In the FEAS interviews we are asking academics to make Judgements on qualities where the criteria (categories and their characteristics) are open to different interpretations. So Research Question 1 addresses whether there is evidence of significantly different interpretations among the interviewers. Are the Judgements of the academic 'agents' sufficiently consistent so that they can be considered as a single category of interviewers, and if so, how are they characterised?

Research Question 2 concerns the possibility of different boundaries. Is the boundary of the engineering knowledge system primarily around academic theory and concepts, with 'softer' skills taking a peripheral role? Or does engineering professional knowledge now encompass a wider range of skills and abilities, as implied by accreditation criteria in the USA and in Australia.

Research Question 3 reflects a more pragmatic and realist approach. We want students to succeed, so we select applicants who will do well in what we know as our disciplinary learning and teaching system. But Question 4 raises the possibility that we have a homeostatic response to the introduction of new criteria and selection processes – interpreting them in ways that will work with the rest of the system.

This research concerns a human organisational system, disciplinary learning and teaching. So it is appropriate to consider theoretical frameworks that are advocated for the study of organisations. Ackroyd (2004) suggests adopting a critical realist perspective because "organisations are structures that are reproduced by the participants in them, but they have emergent properties that bind participants into a particular pattern of relationships." The research questions are about the mechanisms of these relationship patterns, as they affect curriculum change in engineering degrees in UNSW.

Methodology and methods

Research design

Researchers who approach human organisations as complex adaptive systems (Pettigrew et al. 2003; Mitleton-Kelly 2003) advocate using multiple research methods, qualitative and quantitative, as do critical realists (Ackroyd 2009).

Critical realists also point out some limitations of positivist *inductive* methods, such as statistical analysis of a large representative data set to identify apparent relationships. Although these methods can help to identify the context and assist reframing of the organisational processes, they may overlook important organisational mechanisms if used as the sole method of investigation. However, in this case, there are existing accounts in the educational literature enabling us to use what critical realists call *retroductive* logic (Ackroyd 2009) to explain the organisational processes underlying the patterns observed in our own context.

We began by analysing the overall patterns in the FEAS interview scores for internal consistency and for their relationship with measures of student performance in the first year of study. These quantitative analyses aim to show whether, and if so to what extent, the interview is reliably providing a broader measure of student ability than high school exam results. High school exam results for most students are represented by a UAI score which is the standard criterion for selection of undergraduate engineering students.

Student performance measures are based on marks in 1st year courses. We are able to separate out different aspects of assessment, by examining results in two contrasting courses: a 1st year maths course taken by all students, aligning with the theoretical skills that are traditionally valued, and a new 1st year engineering design project course, in which there is explicit assessment of communication skills, teamwork and articulation of engineering design process models. Figure 1 shows how the admission and 1st year study systems are being modelled in this study.

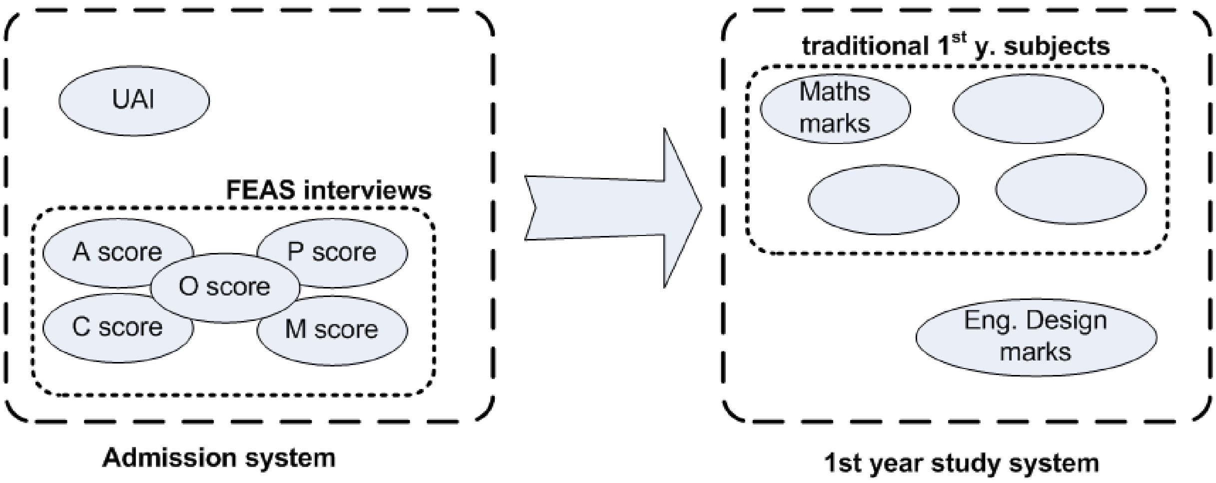

Figure 1.

Analysis of interview scores

The Intraclass Correlation Coefficient (ICC) is a statistical measure of agreement in scores between two or more Judges: 0 for no agreement at all and 1 for perfect agreement. We calculated the ICC for the following measures, in three years of data for:

- interviewer A scores (perceived academic achievement potential)
- interviewer M scores (perceived motivation and interest in engineering)

- interviewer C scores (perceived interpersonal and communication skills)
- interviewer P scores (perceived personal qualities)
- interviewer O scores (perceived overall ability)
- overall arithmetic average of the A, M, C and P scores from each interviewer.

For each of these, we calculated two measures. ICC (1) is the measure of reliability of individual scores. ICC(2) is the reliability when two measures are averaged to form the applicant's final score.

Because each applicant was given scores from an 'interviewer 1' and an 'interviewer 2' we ran multiple regression to see whether the scores depend more on the interviewer than on the selection criteria, and to compare how the A, M, C and P are reflected in the O score.

To relate interview scores with student progression data, we calculated the Pearson Correlation Coefficient for interview scores against maths marks and engineering design marks in 1st year.

Explaining the patterns and processes

Once we have identified some patterns of relationship in the quantitative data, these patterns can be interpreted using theories that have been developed to explain organisational behaviour, and in particular the behaviour of different academic disciplines. The quantitative evidence can then provide a basis for further interventions to develop both student admission processes and curriculum in the Faculty of Engineering.

One advantage of starting with quantitative data analysis is that it provides evidence of a type that engineering academics may be more ready to engage with. Engineering academics can have difficulty with educational research methods that use qualitative or mixed-method research approaches (Borrego 2007).

Results

Interviewer variability

The ICC(1) scores shown in Table 1 represent a modest agreement between individual interviewers and relative consistency between the different years. The corresponding ICC(2) scores show that the average of two interviewer scores is a substantially more consistent estimate of the candidate's abilities than a single interviewer. The ICC (1) scores listed in Table 2 show more agreement between interviewers on A (academic) scores than on the other criteria.

Table 1. Agreement between interviewers' average scores

	ICC(1) 2006	ICC(1) 2007	ICC(1) 2008	ICC(2) 2006	ICC(2) 2007	ICC(2) 2008
interviewer O scores	0.687	0.620	0.678	0.814	0.765	0.808
A + M + P + C	0.660	0.617	0.630	0.795	0.763	0.773

Table 2. Agreement between interviewers' by selection criterion

	ICC(1) 2006	ICC(1) 2007	ICC(1) 2008	Average, all years
A scores	0.676	0.605	0.650	0.644
M scores	0.561	0.551	0.568	0.560
P scores	0.566	0.552	0.522	0.547
C scores	0.573	0.529	0.505	0.536

Relationships between scores

Multiple regression taking the A+M+P+C average as the predictor variable and corresponding O score as the dependent variable, and comparing this with the variation between the two interviewers for each candidate, gave the scores shown in Table 3. In all cases, at least 85% of the variability in overall ratings can be accounted for by the average criteria scores. In other words, overall scores were directly and strongly related to the selection criteria. The size of the correlation coefficients shown in Table 4 indicates that the A score had more than twice the weight of any other variable in forming an overall score, whilst P score appears to be least influential.

Table 3. Determination coefficients for O scores with selection criteria average

	2006		2007		2008		Average, all years	
	Int. 1	Int.2	Int. 1	Int. 2	Int. 1	Int. 2	Int. 1	Int. 2
R^2	0.867	0.874	0.876	0.896	0.873	0.850	0.872	0.873

Table 4. Correlations between selection criteria scores and O score

		2006		2007		2008		Average, all years		
		Int. 1	Int.2	Int.1	Int.2	Int. 1	Int. 2	Int. 1	Int. 2	**Both**
correlation coefficient *R*	A	.467	.414	.456	.492	.433	.507	.452	.471	**.462**
	M	.219	.211	.223	.182	.231	.203	.224	.199	**.212**
	P	.196	.174	.180	.204	.160	.174	.179	.184	**.182**
	C	.203	.279	.210	.179	.267	.186	.227	.215	**.221**

Interview scores and 1st year performance

For Maths marks, only the A score and UAI were related to performance. For Engineering Design marks, M score was (weakly) related to performance. However, A score did not seem to be related to performance. UAI was also related to performance but the relationship was less so than for 1st year Maths.

Conclusions and recommendations

Patterns found

Research Question 1: The FEAS interview scores appear to be reasonably consistent overall. However, interviewer agreement on M, P and C scores is less than for A scores (academic potential).

Research Question 2: Overall, the interview scores, as used for selection of students are not significantly different from exam results (UAI scores) as a predictor of student progression. The component M, P and C scores have potential to indicate other qualities, but these are given less weight and are being assessed less reliably.

Research Question 3: Taken together, the results of the statistical analyses in relation to 1st year marks shows some support for selecting students on other criteria than school exams, and in particular the assessment of motivation and interest, because this appears to relate to performance in the Engineering Design course.

Research Question 4: The results indicate that there is persistent bias in favour of traditional academic assumptions about how engineering knowledge and skill are best acquired. The system is better able to quantify consistently, and to respond to, familiar traditional academic measures than to the new criteria introduced by the FEAS interviews.

Underlying processes at work

These results indicate some characteristics of the UNSW Engineering learning and teaching system. Trowler and Cooper (2002) describe how each Teaching and Learning Regime (TLR) has its own concepts of identity, tacit assumptions, codes of significance, rules and recurrent practices. Argyris (1999, p81) describes how, in any organization, espoused theory often differs from theory-in-use. Theories-in-use are typically learned through socialization, of which the individual may be unaware, and which are accompanied by behavioural strategies that minimize further enquiry. Applying these concepts to university teaching, a critical review of research on teaching beliefs and practices of university academics (Kane, Sandretto and Heath2002) concluded that there is need for more explicit links between espoused theories and teaching practice. In this case, the introduction of new courses and a new admission scheme may not be enough in itself to bring about the desired curriculum change.

The results reported here constitute a stage in this process of measuring and surfacing some of the collective theories-in-use in Engineering. Despite the introduction of new engineering design courses, with broader assessment criteria, these new criteria are not yet fully embedded as part of the academic culture and belief system. By clarifying and making explicit how academic beliefs are influencing student selection and progression, we can make it easier to review and update the curriculum.

One specific change to the interview process, suggested by the statistical analysis, might be to give more weight to the M, C and P scores, and to provide support for interviewers to help them assess these criteria more consistently and rigorously.

Further research

The Faculty is aiming to broaden the boundaries of what counts, and is assessed, as engineering knowledge, and we have provided some evidence of how the traditional boundaries are still influencing outcomes, through judgements made by engineering academics involved in what is ostensibly a changed admission system. The evidence presented here gives little insight into the thinking processes, the tacit assumptions, of academics – and whether or not they are supported by evidence. Nor does it identify which changes would most benefit in changing the system as a whole.

We therefore suggest that this initial work is seen as the1st phase of a longer term action research project, in which the next phase would be to discuss the findings with staff involved in the FEAS curriculum development processes, and to plan changes with them. These changes might also be informed by analysing qualitative data from students, so that we understand what works from their point of view. We have a large amount of student data, only some of which has been analysed with respect to the questions raised by this study.

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