Engineering admissions criteria: focusing on ultimate professional success

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The majority of Australian Universities use performance in the higher school examinations as the primary basis of admission into undergraduate programs for current school leavers. In 2005 an analysis of academic performance in the UTS undergraduate Engineering program showed a relatively low correlation with Higher School Certificate (HSC) results, particularly for students outside the top performance bands. This led to a rethinking of the admissions processes, and the introduction of a broader admission scheme. This scheme incorporated the results of an admission questionnaire which was designed with substantial input from industry, and which aimed to provide an indication of both likely academic success within the degree program as well as (and possibly more importantly) the likely success as a graduate Engineer. The key criteria related to affinity with, and motivations for, an Engineering career and addressed both the attitude and aptitude of students in terms of emotional intelligence characteristics. In this paper we describe the design and introduction of this scheme, and how input from industry was used to construct a questionnaire. We provide an analysis of early outcomes from the process in terms of student performance, and the extent to which course performance correlates to questionnaire results. We also include recommendations on how these schemes may be used to improve the retention and success of Engineering students and how to better match the aptitudes of engineering graduates with the needs and aspirations of Industry and Business.

Keywords: Admissions Engineering Industry Questionnaire

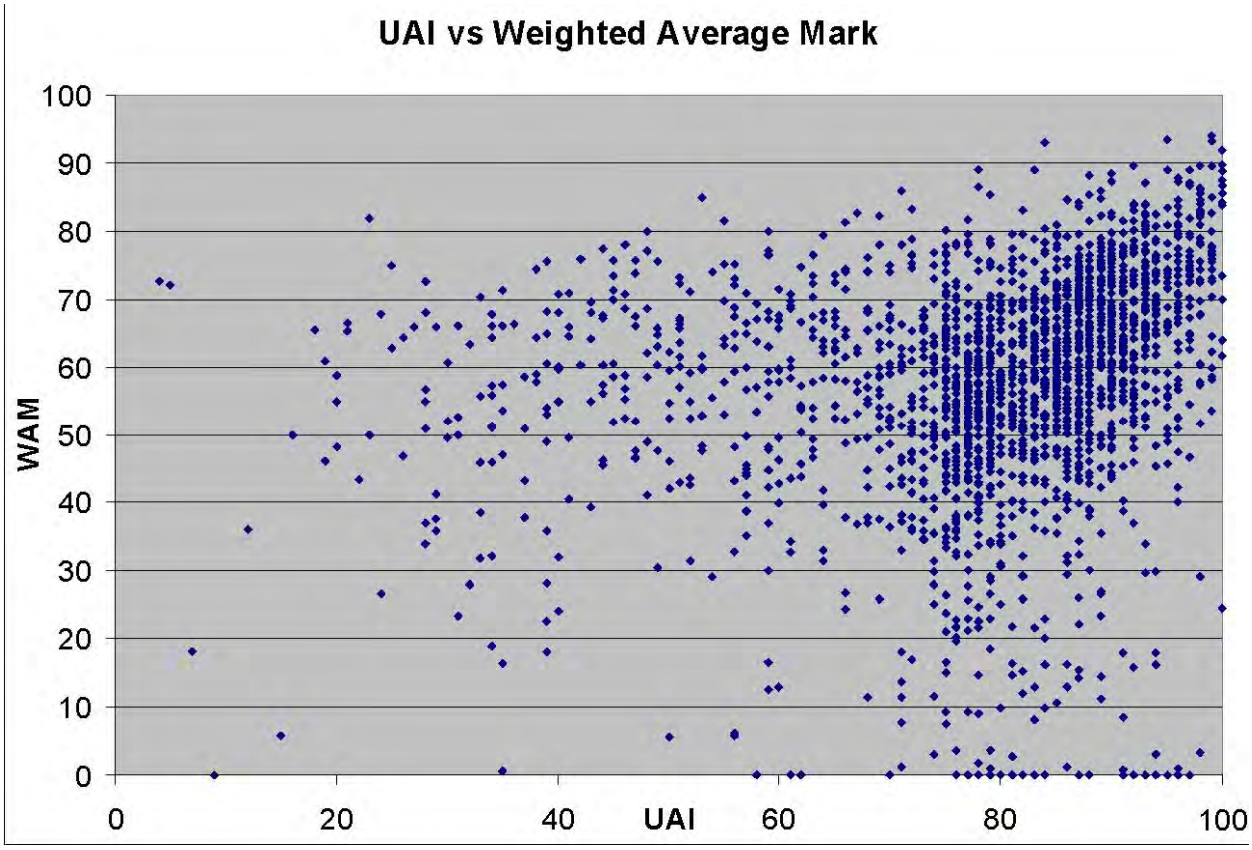
INTRODUCTION

In 2005 the UTS Faculty of Engineering undertook an analysis of the performance of currently enrolled students (using their Weighted Average Mark – WAM – calculated by averaging the marks across all units, weighted by the credit point value of the unit), and compared this to their secondary school performance, as measured by the University Admissions Index (UAI). The result of this analysis – shown in Figure 1 – indicated that whilst a higher UAI was a reasonable indicator of likely performance in their University Engineering courses, the correlation was surprisingly low (r=0.240). This may be a consequence both of capable students performing poorly in secondary schooling but well at University, and capable students performing well in their secondary schooling but poorly at University. The former relates to students who have high academic capability – particularly in relationship to Engineering - but performed poorly in their secondary schooling due to a variety of factors, such as: motivation; illness; family disruptions; etc. The latter relates to students who demonstrated capability in the HSC but performed poorly at University, possibly due to: loss of motivation due to a poor course choice; personal disruption; difficulty in coping with the transition to University, etc.

TABLE 1
Correlation between course performance (as indicated by Weighted Average Mark) and score achieved in each Admission question

Question	**r (Pearson Correlation)**
Please describe a specific aspect of your life which demonstrates your interest in studying Engineering?	0.295
Please describe something specific which you have created and how it demonstrated engineering design?	0.482
You need to design a new wheelbarrow for a client…. Please list the first three questions for which you would seek answers, and why you would ask these questions?	0.368
Please describe the approach you take to solving technical problems?	0.307
Please describe which of your personal attributes and skills you believe will most assist you in a professional Engineering career?	0.413

FIGURE 1
UTS Engineering Student performance: comparing the students' WAM (weighted average mark across all subjects taken in their degree) against their secondary school UAI (University Admissions Index)[1]



These observations on the poor correlation between secondary school and University outcomes (at least in the context of the UTS Engineering course) led to a rethinking of our admissions processes. It was felt that it was appropriate to consider a broader range of factors in determining the offers of admissions into our undergraduate courses. In particular, given the strongly practice-oriented nature of the UTS:Engineering courses, it was felt that the ultimate goal was not to accept students who could succeed in our course, but rather to accept students who were most likely to succeed as professional engineers. In other words, rethinking the admission process emerged from the understanding that the course was a pathway not a destination, and therefore should be focused on that destination. From this perspective a process was commenced of redeveloping the admission criteria.

DEVELOPING A NEW ADMISSIONS CRITERIA

Having accepted that the UTS Engineering admissions criteria ought to take into account the applicants likely success as a professional engineer, it was considered how this might be able to be evaluated. Previous research initiated within the Faculty of Engineering (Scott and Yates, 2002) studied engineering graduates who had been identified by their employers as being 'highly successful'. This research considered the characteristics that were perceived by employers as having contributed to the graduates' success, and the extent to which University courses focused on these characteristics. This research was useful in providing guidance in understanding those personal traits which might be indicative of a course applicant who was more likely to be successful as a professional engineer. This is particularly true when combined with an understanding of the graduate competencies identified by organisations such as Engineers Australia in their National Generic Competency Standards (IEAust, 1999), and the U.S. Accreditation Board for Engineering and Technology accreditation criteria (ABET, 2002).

TABLE 2
Comparison of course performance by students selected pre- and post-introduction of multi-criteria admission process

	Average WAM		
UAI Band	**2004-2005 Sample**	**2006-2007 Sample**	Δ
70-72.5	51.1	54.4	3.3
72.5-75	50.4	55.8	5.4
75-77.5	50.2	57.0	6.8
77.5-80	49.9	56.3	6.4
80-82.5	53.7	58.0	4.3
82.5-85	53.2	57.6	4.4
For comparison only			
90-92.5	63.2	64.8	1.6
97.5-100	73.2	74.1	0.9

[1] Note that students with a UAI below the normal course entry threshold (typically in the mid-70's) would not typically have gained direct entry into the UTS Engineering courses. These students would generally have undertaken other study and/or employment, and subsequently gained entry based on other criteria – often their performance in a vocational or trade course.

[2] These interviews resulted in a number of very interesting observations; for example, one employer observed that the surest sign that an interviewee had an engineering mentality was that, in answering questions, they were keen to be able to draw diagrams to clarify their answers. In other words, he felt that an engineering mentality correlated well with visual thinking.

These sources of information were extended by undertaking a set of structured interviews of 7 employers who had direct responsibility for the selection of graduate engineers to be employed. A series of questions were asked aimed specifically at identifying the characteristics which they were looking for, during the application and interview processes, in making a decision about which graduates they believed would be most likely to be a successful graduate engineer.[2]

Various surveys and questionnaires used for entry into Engineering programs elsewhere have been investigated. Almost all of these have a strong emphasis on evaluating specific technical knowledge, such as the Graduate Aptitude Test in Engineering (GATE) test used by many Universities in India, and which focuses on an evaluation of the content covered in undergraduate Engineering programs (Palit, 1998). Other institutions have developed specialised tests (such as NUS in Singapore) that fundamentally look at the broader affinity with Engineering and general aptitude - but these tend to be sparse on detail.

From these sources of information a questionnaire was developed which contains questions aimed at evaluating those characteristics that previous research had indicated as possible important indicators of professional engineering career success. The key elements of this were student motivation, interpersonal skills, design talent and technical aptitude. Example questions included in the questionnaires include:

- Please describe a specific aspect of your life which demonstrates your interest in studying Engineering?
- Please describe something specific which you have created and how it demonstrated engineering design?
- You need to design a new wheelbarrow for a client…. Please list the first three questions for which you would seek answers, and why you would ask these questions?
- Please describe the approach you take to solving technical problems?
- Please describe which of your personal attributes and skills you believe will most assist you in a professional Engineering career?
- Please describe what you expect to gain from a UTS:Engineering degree?

A clear evaluation criteria was also developed to facilitate the evaluation process. This questionnaire was then used to modify the UTS:Engineering admissions process for current school leavers (CLS applicants). These applicants are made offers of a place in an Engineering course on the basis of a multiple-criteria entry which uses both an adjusted UAI (Universities Admission Index) or equivalent and the optional questionnaire.

The adjusted UAI is determined by adding additional bonus points to the base UAI for the applicant's first order rank. Bonus points are added to the UAI on the basis of a specified set of subjects undertaken by the applicant. This essentially reflects both preparation, but (more importantly) is believed to be correlated to likely student motivation and interest in Engineering (though this has yet to be formally evaluated).

Those students whose adjusted UAI fell below a given threshold could also complete the questionnaire. (The threshold is currently set at 85, based partly on a more detailed analysis of the data depicted in Figure 1 – which indicates that above this threshold, the UAI is a sufficient indicator of likely success). A weighted combination of adjusted UAI and questionnaire score is then used to rank applicants, and offers are made until all places are filled. Information on the process was provided to all CSL applicants through a range of channels. These include publications of the University Admissions Centre (UAC), open days, mail-outs to schools, and through the Web.

RESEARCH FINDINGS AND DISCUSSION

The modified admissions process was implemented initially for the Autumn 2006 intake of students, and has been used for all subsequent intakes (Spring 2006, Autumn and Spring 2007, Autumn 2008). Over these five intake periods the Faculty of Engineering has made 2001 offers of places into undergraduate degree programs, of which 742 have been made to CSL applicants in the band where the questionnaire is taken into consideration (i.e. adjusted UAI < 85), with the remainder being either non-CSL applicants (i.e. typically mature-age applicants) or CSL applicants with a UAI above the threshold of 85. Of these 742 "questionnaire-based" offers, 609 (82.1%) accepted the offer.

To evaluate the effectiveness of the approach we have undertaken two forms of analysis. The first was to compare the performance of current low-UAI students with the performance of low-UAI students who were admitted prior to the introduction of the multiple-criteria admission scheme.

Table 2 provides a comparison of the performance of students admitted in the period 2004-2005 (i.e. prior to the introduction of the multiple-criteria process) with the performance of a sample of students admitted in the period 2006-2007 based on the questionnaire process. A comparison of the performance of higher-UAI students (i.e. not selected based on the questionnaire) is included to demonstrate the extent to which overall performance changes may have influenced the comparison.

We recognise that the use of historical data in supporting a longitudinal comparison such as this is statistically problematic (given various other activities and/or initiatives which may have affected student performance over this period) it is nevertheless a useful indicator, and would appear to support the argument that the modified admissions process is leading to improved performance outcomes – possibly through selecting those applicants who are more likely to succeed.

It is also worth noting that this comparison – i.e. performance in the course – was not the ultimate objective of the changed admissions process. Rather, it was intended to support the admissions of those students who are most likely to develop into successful professional engineers (as distinct from admitting those students who are

likely to perform highly in the course). This outcome can obviously not be evaluated for a significant period – at least until the students have begun their professional careers.

The second form of analysis was to compare the course performance (by WAM) of those students who have been admitted using the new process with the evaluation (by senior academics) which they received on their questions. This would allow us to evaluate the ability of the various questions to indicate likely capability, and to progressively refine the questions over time. This was carried out using a random sample of 100 students admitted in Autumn 2006 (using course results from 2006 and 2007) and Autumn 2007 (using just 2007 results) and who had completed the questionnaire. For these students we compared their performance in the first year of the course with their scores for each of their answers to the questions in the admissions questionnaire. The resultant correlations are given in Table 1. With a sample size of 100, and $\alpha=0.05$, then the minimum r to give significance is 0.195.

As can be seen from this table, all questions have a positive correlation with performance in the course, which is above the level of statistical significance. This would support the argument that the questionnaire provides additional value in the process of selecting students for admission to the undergraduate degree program.

CONCLUSIONS

Whilst it is still relatively early in the implementation of the multiple-criteria admission processes, early data appears to indicate that it has the potential to provide students with the ability to plan for improvements in performance in their course. Ultimately the objective is to admit students who develop into highly successful professional engineers (rather than necessarily performing well in the academic program) – and certainly the additional criteria were designed specifically to support this. It is however too early to be able to evaluate whether this objective is being achieved. One potential avenue for evaluation, for which we are currently considering the feasibility, would be to determine whether the performance on the additional admissions criteria are correlated to the performance of our students in their extended internship placements. These occur much sooner (typically a 6 month period in the students' second year of study, and another 6-month internship late in their course) and hence might provide useful indicators of the ability of the questionnaire to discriminate likely workplace success.

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