Full Paper

"Success" at a tertiary education level is often measured by some combination of individual unit pass rates, individual marks and entire degree completion rates. These measures are often significantly influenced by students at the two ends of the performance spectrum, and can often fail to identify how the bulk of the students in the middle are performing other than simply 'passing'. Analysis by interested academics is often carried out by plotting absolute marks against some chosen criteria. This paper aims to consider if there are other ways to identify and measure success.

Background

A number of studies have explored the extent to which issues such as high school background can predict subsequent student University performance. Wurf and Croft-Piggin (2015) consider the Australian Tertiary Admission Rank (ATAR) as well as a range of other measures. Lowe and Johnston (2008) studied the correlation between students' undergraduate performance and student responses to a range of broader questions regarding their motivation and aptitude prior to commencing their University studies. Knipe (2013) also considered whether ATAR could be used to predict the likelihood of students successfully completing degree programs. Lowe, Wilkinson & Johnston (2015) analysed a large data set of university entry scores and compared them with yearly average marks in engineering degrees in order to investigate correlations between specific subject choices made at high school and their engineering degree performances at a gross level, and are seeking to use this paper to further enhance this analysis and interpretation.

This paper investigates whether "improvement", as defined by improving the ranking of students over the duration of their degree program with respect to marks within their cohort, is a reasonable measure of success. Clearly the net improvement as measured by rank within a cohort must be zero, for every student who moves up in a ranking list of students another student must move down. This paper therefore seeks to investigate if any specific groups, identified by gender or secondary school subject performance show a statistically meaningful level of improved performance. The results of this analysis should improve admissions processes through supporting the identification of students who are most likely to improve through the course, and maybe also establish an ability to provide better support to those students who are identified as most likely to struggle.

Methodology

Data Set

The analysis considered just over 4100 students admitted to engineering, IT and project management degrees at The University of Sydney in the period 2006-2014. Only local students, who had recently completed the NSW Higher School Certificate (or similar interstate high school qualification), were considered. International students, or students who had transferred from another university or TAFE were not considered. Recent HSC students comprise approximately 60% of the starting cohort. By limiting the data set to recent HSC students it was possible to have a common starting point by which to rank students.

Of these 4100 students, nearly 1900 were categorised as having "completed" their degree programs and were defined as having completed at least 4 years of university study. This definition therefore incorrectly includes a small number of (generally poor performing) students who spent at least 4 years at university but failed to complete their degree programs. It was not easily possible to remove these students from the dataset.

It should be noted that these figures do not imply that only 45% of students complete their degree programs since most of the students who were admitted in 2012-2014, and included in the full data set of 4100, have not yet completed their programs.

Ranking and defining "improvement"

Students were classified according to the year in which they started their degree programs. Students were then ranked in order of their ATAR, and that ranking was then expressed in terms of statistical deciles.

Individual student WAMs (weighted average marks) were calculated, based on their university performance after 1 year and on completion. Similarly, students were ranked, and then condensed into deciles, based on these WAMs.

For the purposes of our analysis, "improvement" was then defined as a change in a student's performance decile over a period of time. Students were only ever ranked against their starting cohort. Improvement in the first year could be measured for all 4100 students – and this included students who subsequently did not complete the degree. Improvement from high school to completion, or from year 1 to completion, was calculated with respect to the smaller cohort of 1900 who did complete the degree.

"Significant improvement" was defined as improving by two more deciles. 'Significant decline" was defined as reducing your decile by two or more. "Same or small change" was defined for cases when a student's decile changed by 1 or 0.

Sub cohorts were further analysed by gender, level of maths at the HSC and level of English at the HSC.

Findings and Discussion

General observations

Table 1 summarises the overall improvements and decile changes for all students for the following time periods:

- From completion of high school studies to of the end of year one of university studies.
- From year one of university to completion of undergraduate studies.
- From high school completion to university completion.

Table 1 contains the complete breakdown by decile change. There are 19 possible levels of decile change ranging from a very large improvement of +9, to a very large drop of -9. After reviewing the data, it was decided that this level of granularity was excessive and the outliers lacked meaning. Subsequently improvement was more broadly broken down into 3 categories only, "significant improvement", "same or minor change" or "significant decline".

Table 1: Decile change for all students, and gender comparison

	School to year 1			Year 1 to completion			School to completion		
Decile Improvement	Total	Male	Female	Total	Male	Female	Total	Male	Female
9	0.0%	0.2%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
8	0.2%	0.2%	0.7%	0.1%	0.1%	0.0%	0.1%	0.2%	1.2%
7	0.4%	0.9%	0.9%	0.6%	0.4%	1.2%	0.9%	0.6%	3.3%
6	1.1%	1.2%	0.9%	0.9%	0.6%	2.4%	1.8%	1.7%	2.1%
5	2.6%	2.1%	2.7%	2.1%	2.1%	2.1%	2.6%	2.6%	3.3%
4	4.0%	3.9%	5.4%	2.6%	2.6%	2.7%	5.0%	4.0%	5.7%
3	6.9%	5.5%	7.6%	4.5%	4.0%	6.9%	6.9%	7.1%	8.1%
2	9.8%	8.5%	11.7%	6.0%	6.1%	5.7%	10.2%	9.7%	13.7%
1	15.8%	14.1%	15.5%	14.9%	15.3%	12.8%	14.0%	12.7%	12.2%
0	20.7%	20.4%	21.7%	28.8%	29.9%	23.3%	17.9%	17.7%	19.1%
-1	14.3%	16.0%	15.0%	21.2%	21.0%	22.4%	12.6%	14.6%	11.3%
-2	9.2%	10.4%	7.2%	10.4%	10.3%	11.3%	10.4%	10.9%	6.9%
-3	5.9%	7.4%	5.3%	5.5%	5.8%	4.5%	7.3%	7.1%	5.7%
-4	4.2%	4.4%	2.2%	1.4%	1.1%	2.7%	4.3%	5.1%	4.5%
-5	2.2%	2.8%	1.9%	0.5%	0.4%	0.6%	2.7%	2.9%	0.9%
-6	1.1%	1.4%	0.0%	0.2%	0.1%	0.3%	1.7%	1.8%	2.1%
-7	0.9%	0.5%	0.2%	0.2%	0.1%	0.6%	1.1%	1.2%	0.0%
-8	0.3%	0.2%	0.0%	0.1%	0.0%	0.3%	0.4%	0.1%	0.0%
-9	0.3%	0.0%	0.0%	0.1%	0.1%	0.3%	0.0%	0.0%	0.0%
Significant improvement	24.1%	22.4%	30.9%	16.8%	15.9%	20.9%	28.0%	26.0%	37.3%
Same or minor change	50.8%	50.5%	52.2%	64.9%	66.2%	58.5%	44.5%	44.9%	42.7%
Significant decline	25.0%	27.2%	16.9%	18.4%	17.9%	20.6%	27.5%	29.1%	20.0%
Total	4120	3278	847	1894	1559	335	1894	1559	335

The overall statistics indicate there is a significant amount of “performance mobility”. For example, nearly half of the students significantly change their ranking during the period of their university study. Students therefore should not be adversely classified at their entry to University as performances suggest that their academic success is associated with a number of factors that they can influence. Previous studies demonstrate a broad correlation between ATAR and WAMs over the duration of the degree, with a fair amount of scatter (eg Figure 1, from Lowe, Wilkinson & Johnston (2015)). Table 1 enables us to appreciate the extent of this scatter in a different way, rather than as a purely statistical correlation number.

There is also a significant amount of mobility within the course itself, with a third of the students significantly changing their ranking from year 1 to the completion of their programs, however there appears to be more stability of rankings after first year. Further incremental improvements from year 1 to year 2, or year 3 are yet to be analysed.

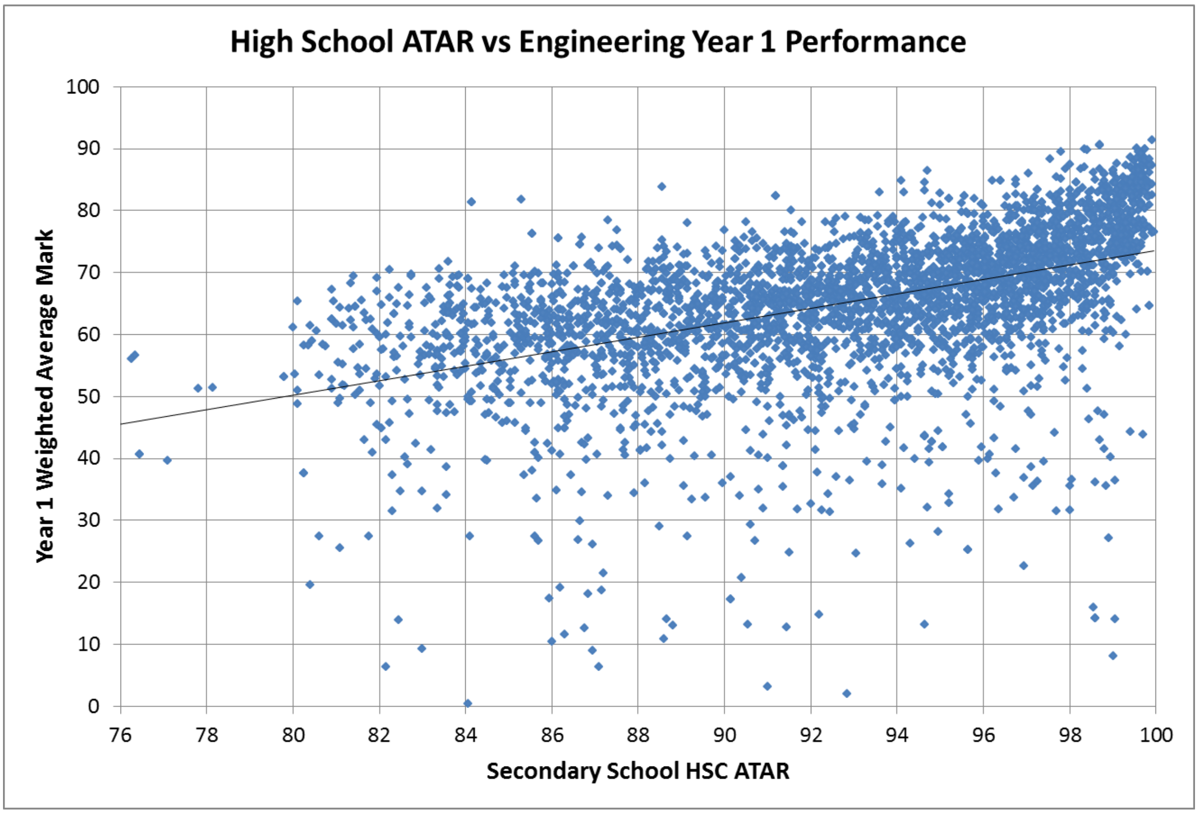

Figure 1: ATAR vs WAM for First Year Engineering Students (Lowe, Wilkinson & Johnston 2015).

Gender

Table 1 also distinguishes between gender performances. Currently, females represent between 20-25% of the total engineering/IT/project management cohort.

A significantly higher percentage of female students improve their relative rankings over the course of the degree, and similarly a significantly lower percentage experience a decline in performance.

Studies have reported that females “perform better” in engineering related fields (eg Lowe, Johnston & Wilkinson (2015), with it being often proposed (eg Patton, Bartrom, Creed (2004)) that the general level of maturity in the 18-21 age bracket of females being a significant contributing factor.

Influence of Maths and English

Tables 2 & 3 consider levels of ranking change by considering the level of Maths and English attempted at high school.

For the benefit of readers not familiar with the NSW HSC range of subjects, we briefly summarise the differences, but detailed information is available from BOSTES (2015).

- General maths is a non-calculus based course. It covers areas such as Financial Mathematics, Data and Statistics, Measurement, Probability, and Algebra and Modelling in contemporary contexts chosen for their ongoing relevance to the students' everyday lives and likely vocational pathways. This course is not considered to be adequate preparation for an engineering undergraduate degree.

- Mathematics (sometimes called "regular mathematics" or "2 unit maths"), is the primary calculus based course. Some of the key content includes integration and differentiation, probability, and geometry.
- Mathematics Extension 1 (sometimes called 3 unit maths), is a more thorough and detailed study of similar topics to regular mathematics with nominally 50% more time devoted to the subject. This course is listed as 'assumed knowledge" for engineering at The University of Sydney.
- Mathematics Extension 2 (sometimes called 4 unit maths) covers advanced topics such as complex numbers, conic sections and mechanics, and is designed for the highest maths performers. The learning content is nominally twice that of regular maths.
- In English (Standard), "students learn to respond to and compose a wide variety of texts in a range of situations in order to be effective, creative and confident communicators" (BOSTES 2015), whereas in English (Advanced) "students apply critical and creative skills in their composition of and response to texts in order to develop their academic achievement through understanding the nature and function of complex texts." (BOSTES 2015). Both subjects have nominally the same level of learning commitment.
- Extension English (sometimes called 3 unit or 4 unit English) are 50 or 100% greater in content compared to standard English. It is designed for students "who choose to study at a more intensive level in diverse but specific areas. They enjoy engaging with complex levels of conceptualisation and seek the opportunity to work in increasingly independent ways." (BOSTES 2015)
- English as a Second Language (ESL) is "designed for students from diverse non-English-speaking, Aboriginal or Torres Strait Island backgrounds as designated by the course entry requirements. The students engage in a variety of language learning experiences to develop and consolidate their use, understanding and appreciation of English, so as to enhance their personal, social and vocational lives." (BOSTES 2015).

It is often claimed that the level of maths (extension 2 v extension 1 v regular maths) is a good indicator of university performance, but recent unpublished analysis at the University of Sydney also suggests that the level of performance (often called the band) is a key issue (e.g. higher performance in a lower level of maths may be preferred). The analysis in this paper merely examined the relationship to the level of Maths or English attempted, not necessarily the grade or mark in the subject. Because of the reasonably high ATAR cutoff for Engineering, most students achieve high bands in most subjects in any case.

Table 2: Impact of Level of Mathematics

	Maths Ext 2		Maths Ext 1		Maths		General/No Maths	
	School to Year 1	School to completion	School to Year 1	School to completion	School to Year 1	School to completion	School to Year 1	School to completion
Significant improvement	26.6%	35.9%	23.3%	24.9%	21.8%	17.8%	17.8%	16.0%
Same or minor change	54.8%	47.0%	48.3%	43.0%	47.9%	42.2%	55.4%	52.0%
Significant decline	18.6%	17.1%	28.3%	32.1%	30.3%	39.9%	26.7%	32.0%
Total	1506	715	1843	897	670	258	101	25

Table 3: Impact of Level of English

	English Ext 1/2		English Advanced		English Standard		English ESL	
	School to Year 1	School to completion	School to Year 1	School to completion	School to Year 1	School to completion	School to Year 1	School to completion
Significant improvement	40.0%	42.7%	23.7%	27.1%	12.8%	18.8%	25.5%	30.8%
Same or minor change	49.4%	38.1%	52.4%	46.2%	44.6%	42.0%	45.5%	42.3%
Significant decline	10.6%	19.3%	23.8%	26.7%	42.6%	39.2%	29.0%	26.9%
Total	453	218	2973	1349	549	250	145	78

There appeared to be a positive correlation between levels of improved performance versus maths level attempted. Slightly higher levels of "improved performance" are observed for students with higher levels Maths. Of course, students with Extension 2 Maths are more likely to have higher ATARs and be in the higher deciles to start with, and hence by the definition of improvement used in this paper, it is difficult for them to show improvement.

Surprisingly the level of English studied yielded different levels of improved performance. Students studying the highest levels of English (extension 1 or 2) showed much higher improvement levels (40% improved their ranking) and only a small percentage decreased. ESL (English as a second language) students also showed a greater level of improvement compared to standard English students.

While the phenomenon of "cause and effect" should always be considered before making conclusions, the results do reinforce the importance of English for the performance of students in engineering related fields. Due to increased emphasis on communication in assessment tasks, the more varied English speaking and writing backgrounds of students is likely to be a key influencing factor. Engineering related fields do not necessarily have a student cohort with a wide a range of Maths skills. ESL students possibly flourish due to a more significant improvement in their English skills while at university.

Conclusions

This paper has used an innovative approach to measure academic success at university and by using a change in performance ranking within a cohort, or "improvement" in performance, this paper has quantified the impact of various parameters on a student's performance.

While ATAR is broadly accepted as a reasonable predictor of university performance, this paper suggests that nearly half of the undergraduate cohort significantly change their performances with respect to their peers as they transition through their degree programs.

Previous observations that females perform better than their male counterparts in engineering fields is reinforced, as well as highlighting the significance and value of English reading, speaking and writing skills.

The analysis in this paper has been intentionally simple and broad to allow broad trends to be identified. It is hope that this will assist engineering educators in assessing if current practice needs to be adjusted if particular cohorts appear to be under-performing, and similarly learn from what might be contributing to achieve better performing cohorts.

References

Wurf, G., & Croft-Piggin, L. (2015). Predicting the academic achievement of first-year, pre-service teachers: the role of engagement, motivation, ATAR, and emotional intelligence. Asia-Pacific Journal of Teacher Education, 43(1), p75-91.

Lowe, D., Johnston, A. (2008), "Engineering Admissions Criteria: Focusing on Ultimate Professional Success," in Proc. of 2008 WACE Asia Pacific Conf, Sydney, pp 354-360

Lowe, D., Johnston, A. and Wilkinson, T., (2015), "The Validity of High School Performance as a Predictor of University Undergraduate Engineering Performance," Proceedings of the 43rd Annual Conference of the European Society for Engineering Education. June, 2015. Orleans, France. http://www.sefi.be/?page_id=6043

Knipe, S. (2013). University course completion and ATAR scores: is there a connection?, The Journal of Educational Enquiry, 12(1).

Patton, Wendy, Dee A. Bartrum, and Peter A. Creed. "Gender differences for optimism, self-esteem, expectations and goals in predicting career planning and exploration in adolescents." International Journal for Educational and Vocational Guidance 4.2-3 (2004): 193-209.

BOSTES, (2015), Board of Studies Teaching and Education Standards, NSW, http://www.boardofstudies.nsw.edu.au/syllabus_hsc/m retrieved 12 October 2015.

Copyright