# The Influence of University Entry Scores on Performance in Engineering Mechanics

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***Abstract**: An ongoing study into the causes of poor student performance in engineering mechanics has uncovered some intriguing data on the relationships between students' university entry scores and their performance in engineering mechanics courses. Statistical analysis has shown that the expected correlations between this key measure used to determine students eligibility for study and engineering mechanics score either do not exist, or are too weak to base educational interventions on. However, students' entry scores have instead been shown to provide a 'risk factor', whereby students' risk of failing the subject can be determined by entry score ranges. These risk factors may be used to gauge the effectiveness of educational developments in engineering mechanics, particularly when faced with small data sets.*

## Introduction

"Students just don't have the maths anymore, that's why we have such high failure rates"

"We are accepting too many students with low University entrance scores"

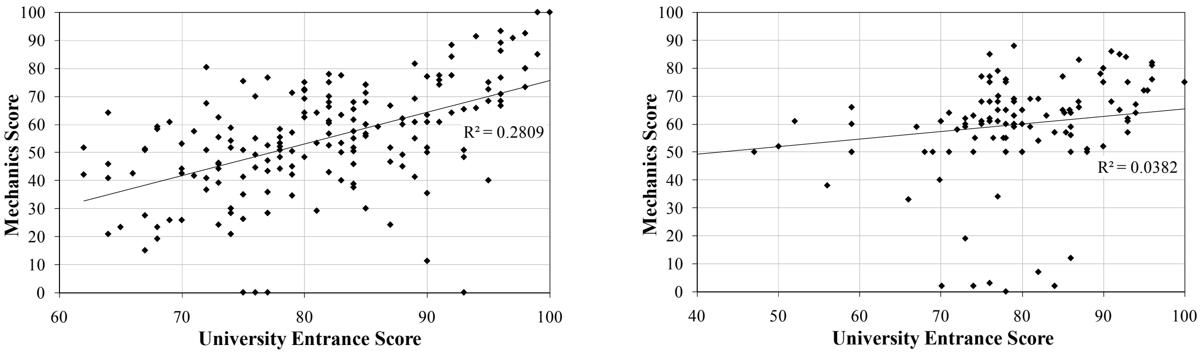
"Not enough students have done physics in high school"

These assertions will be instantly recognisable to anyone who has ever attended some sort of undergraduate curriculum meeting, but how accurate are they? This is what the team of an Australian Learning and Teaching Council funded project to investigate and address high failure rates in engineering mechanics courses intended to find out among other commonly cited causes of poor performance. Academics at the University of Wollongong, the University of Tasmania, the University of Technology, Sydney, and the Australian Maritime College investigated the students' school academic history, and subsequent performance in first year mechanics courses to determine the extent to which achievement at Year 12 is an indicator of performance at university and whether the lack of high-level maths or physics at year 12 are contributing factors to failing mechanics courses.

Previous work by Dwight and Carew (2006) and Tumen, Shulruf and Hattie (2008) has shown limited correlations between academic history and university performance. A Federal government study by Urban et al. (1999) also showed that while tertiary entry scores are good predictors of performance (in terms of degree completion) between high and low scores, no significant differences exist between the top four entry score deciles, where the majority of Engineering students lie. Interestingly, Tumen, Shulruf and Hattie (2008), also singled out engineering students as more likely to leave after first year than other students, indicating that engineering could indeed be a special case with its own set of difficulties. This current study examines the correlation between student performances in entrance exams and first year mechanics courses as well as the use of the university entrance score as a predictor for failure.

## Correlation of Entrance Scores and Mechanics Results

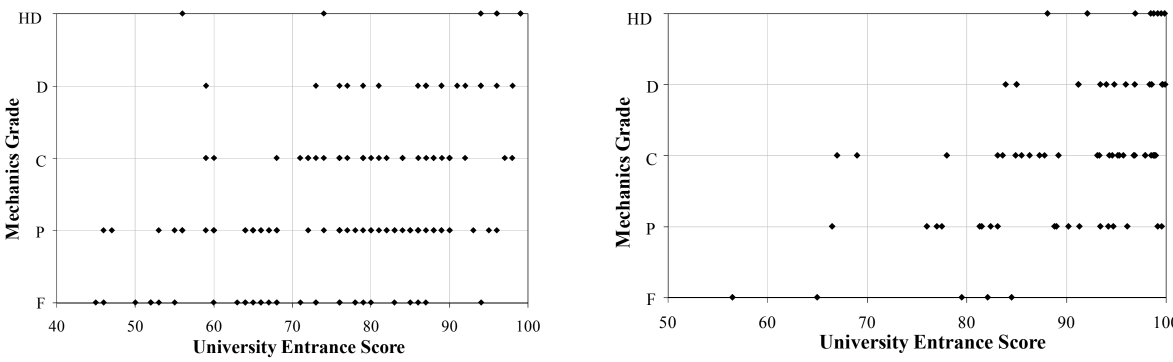
University entrance scores (UES), which are used as key eligibility criteria for university applicants, were collated from the four participating Universities: the University of Wollongong, the University of Tasmania, the University of Technology, Sydney, and the Australian Maritime College for students who had completed a first year mechanics course. The entrance scores were available for nearly all students who had entered following completion of year 12 exams; however scores were not available for students entering through different pathways such as mature students and international students.




**(a) Institution A** **(b) Institution B**

**Figure 1: University entrance score vs mechanics score**

These entrance scores were then plotted for each student against their result for a first year mechanics course, examples of such plots are shown in Figure 1 for Institutions A and B. There is a very large amount of scatter in both sets of data and although it could be argued that there is generally a positive association between the UES and the mechanics course score for Institution A, this is predominantly due to those students entering with a UES above 95 who generally have performed well in the mechanics course. A linear regression line has been fitted to both sets of data and the $R^2$ value, or coefficient of determination, determined as 0.2809 for Institution A and 0.0382 for Institution B; this indicates a very weak relationship between the UES and performance in the mechanics course.




**(a) Institution C** **(b) Institution D**

**Figure 2: University entrance score vs mechanics grade**

The correlation between UES and mechanics grade for Institutions C and D are shown in Figure 2. Again the relationships appear to be very weak; for example at Institution C students gaining higher distinction grades entered with UES between 56 and 99. Further analysis of the data was conducted to determine statistical measures including the Pearson product-moment correlation coefficient, Student's t-test and Levene's test. Whilst lack of space precludes their presentation in this paper, these statistics exhibited similar weak correlations between the UES and performance in the mechanics course.

Therefore based on an analysis of mechanics course scores and grade distributions, it appears to be impossible to reliably predict students performance based on their overall performance in high school.

It is evident then that academic history can only tell us part of the story of why students fail mechanics, but which part? This prompted the authors to look at the statistics in a different way. Borrowing from the world of medical statistics, it was decided to investigate the variation in 'risk of failure' of different student groups.

## Risk Factor

The concept of risk factor is used extensively in the medical world when presenting aspects which increase a person's chances of developing a disease. The technique was first proposed by Kannel et al. (1961) in study which isolated the major risk factors associated with heart disease: high blood pressure, high cholesterol levels and certain irregularities in the electrical patterns in the heart.

A risk factor is calculated by comparing the risk of those exposed to the potential risk factor to those not exposed as follows:

$$\text{Risk Factor} = \frac{\text{number of students experiencing event}}{\text{number of students exposed to risk factor}}.$$

It may be adapted to the educational field by assessing the risk of failing a course by relating the number of students who failed a course entering with a specific UES compared to the total number of students entering with that UES:

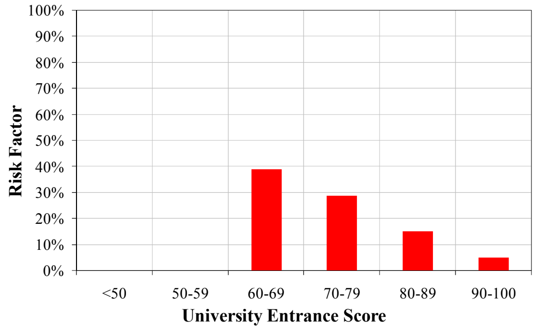
$$\text{Risk Factor} = \frac{\text{number of students failing course}}{\text{number of students with university entry score in specific range}}.$$

This allows a comparison of the risk of those who entered the course with a high university entrance score, to those who entered with a low one. This approach may not only shed light on whether students entering mechanics courses with low UES are more prone to failing, but also add some statistics to the debate over which students should be accepted into engineering degree programs.

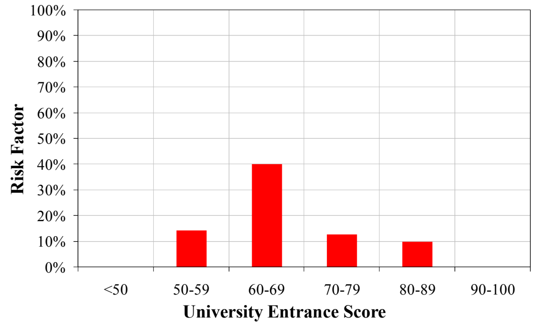
The risk factor for the student cohorts from each participating university were determined for a range of university entrance score and are presented in Figure 3. These plots show the percentage of students who failed the mechanics course for various ranges of university entrance scores, or the risk factor of failing for a given UES. For Institution C, students entering with a UES of less than 50 can be seen to have a risk factor of 50% of failing the mechanics course; this risk factor reduces as the UES increases with a risk factor of only 4% for those students with a UES between 90 and 100. Similar trends can be clearly seen for Institutions A and D with an increase in risk factor for a reduction in UES. In contrast the data for Institution B exhibits a difference tendency, with a drop in risk factor for a UES of 50 to 59 when compared with a 60 to 69 UES.

The reason for this difference in risk factor for Institution B may be partially explained through studying the relative numbers of students in each UES category. Figure 4 shows the number of mechanics students in Institutions B and C in each UES band as a percentage of the total number of students. This shows that when compared to Institution C (the figures for the other institutions are somewhat similar) there are relatively low numbers in the Institution B UES bands 50-59 and 60-69, which may being skewing the data to some extent.

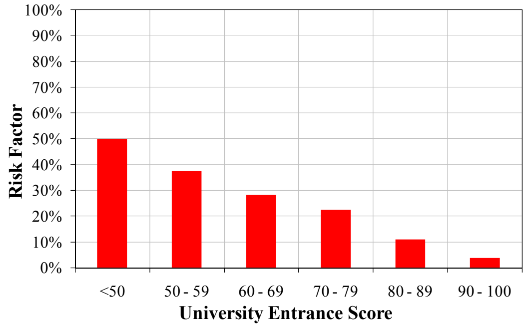
The data in Figure 3 also allows a comparison of student failure rates for the different institutions to be made. There is a significant variation between institutions, with students at Institution D having the highest risk factor of failing, whilst students at Institution B have the lowest risk factor. Whether this difference is due to differences in teaching methods, student capability or course difficulty is not evident.



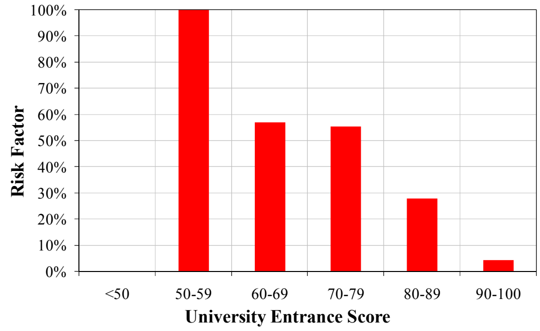

**(a) Institution A**




**(b) Institution B**

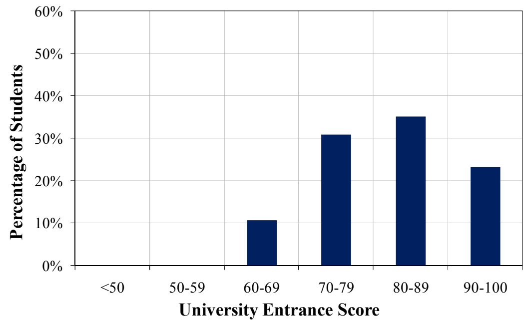



**(c) Institution C**

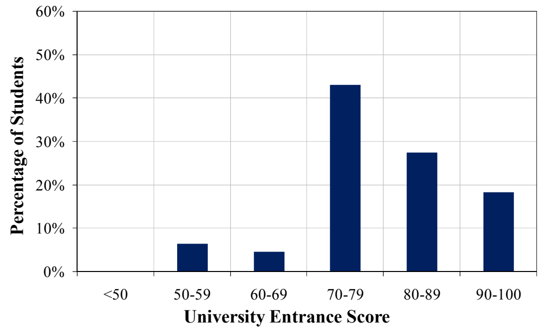



**(d) Institution D**

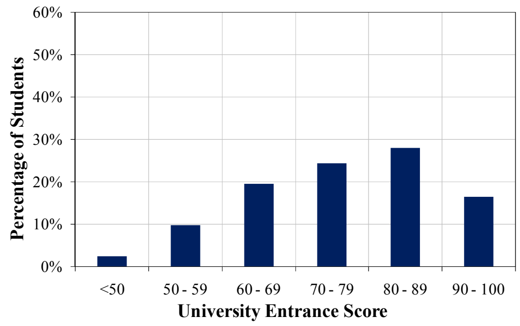
**Figure 3: Risk factor of failing mechanics based on university entrance score**



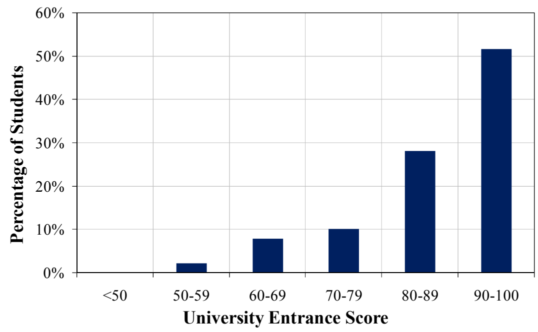

**(a) Institution A (sample size = 168)**




**(b) Institution B (sample size = 109)**




**(a) Institution C (sample size = 165)**




**(b) Institution D (sample size = 89)**

**Figure 4: Percentage of students in university entrance score ranges**

The use of the risk factor may be extended to determine the amount by which an occurrence is more likely to happen than average. Figure 5 shows the times more likely a student is of failing mechanics are plotted for each UES band; where a student undertaking mechanics with a UES of less than  can be seen to be 2 ½ times more likely to fail mechanics than a student with the average risk factor for this institution (19%).

The influence of taking other courses on student performance in mechanics can also be investigated using a risk factor approach. This is illustrated in Figure 6, where the risk factors for participation, and non-participation, in an extension maths programme student at Institution A are presented. There is a stark difference in the data for the two groups with students who participated in the extension programme having a risk factor of 24% compared to a risk factor of 45% for those students who did not participate.

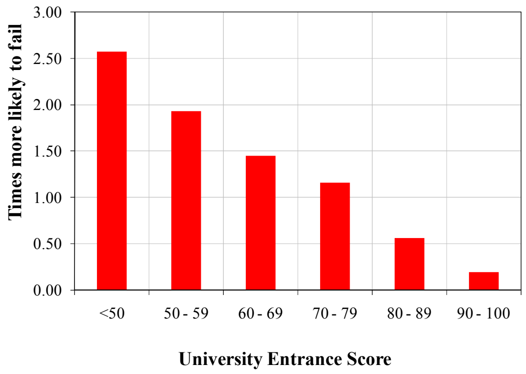



**Figure 5: Times more likely students are of failing mechanics than average (Institution C)**

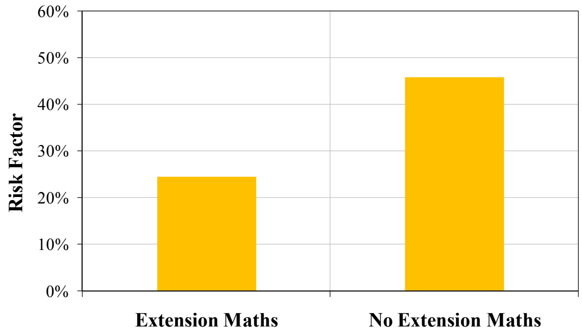



**Figure 6: Risk factor of failing mechanics based on participation in extension maths programme (Institution A)**

## Discussion

The poor level of correlation between UES and engineering mechanics performance is surprising, particularly since UES, combined with the appropriate choice of subjects completed are the criteria defining admission into university degree programs. Indeed, McKenzie and Schweitzer (2001) conclude that previous academic performance gives the best indication of performance in first year university, more so than other factors such as integration into university, self efficacy, and employment responsibilities, which are also important, but to a lesser extent.

One reason why UES is not a particularly accurate predictor of performance in first year mechanics is that it contains a considerable diversity of students' academic background. The score is based on a number of best scoring tertiary entry level subjects, and it does not necessarily provide an indication of performance in units that assist in preparing students for engineering mechanics, such as mathematics and physics. In addition to meeting a minimum entrance score requirement, students seeking admission into an engineering degree program often must have completed base-level mathematics and physics units. Completing these units is sufficient to 'open the door' into studying engineering, however, some students also complete higher level units in mathematics, physics and chemistry. The results presented in Figure 6 suggest that students having studied higher level maths are in a sub-group with significantly reduced risk of factor of failing. This suggests that school subject choice may potentially be as important as UES as a performance predictor. However, this result must be interpreted with care as students in this sample group may have also achieved higher UESs.

Despite the lack of correlation between UES and performance in engineering mechanics, this study has shown that UES can be used to identify groups at higher risk of failure. The trend of students with lower UES is consistent in all four institutions studied. This information may be used in several areas. The risk factor approach may also be used to emphasise the importance of subject choice in addition to maximising their UES. The risk of failure may be expressed in a positive form as a chance of success, and used to inform School students that they have better chance of doing well in engineering mechanics if they complete higher level mathematics and physics. This type of positive reinforcement may have beneficial self efficacy effects, which are known to play an important role in academic performance (McKenzie and Schewitzer, 2001). If students believe they will succeed, they are more likely to succeed.

Students deemed to be at higher risk of failing may benefit from direct intervention measures in the form of additional support programs. This is a common practice in many university courses where subgroups are identified with a different academic background. For example, language courses are offered to international students; additional tutorials for students that have entered programs through a bridging courses instead of having completed usual prerequisite units; and basic computer skills courses. Could an additional tutorial program be introduced with the aim of improving performance of those with high risk of failing engineering mechanics? The risk factor approach may also be used to provide a framework for assessing the effect of changes made to a unit, such as changes to unit delivery or curriculum; for example, assessing if an intervention measure is actually helping those with higher risk of failure.

The results from this study are based entirely on students with available UES data, which in this case consists mainly of recent school leavers. Students that enter university through other pathways such as international students, mature aged student, or students switching from other programs may not be well represented in this data set.

## Conclusion

This study has shown that university entry scores from students at four tertiary institutions fail to provide a good predictor of performance in first year engineering mechanics. Presenting the results in terms of a risk factor of failing engineering mechanics shows a clear trend that students with low UES have an elevated risk of failure. The risk factor approach is also identified as a useful tool in developing potential intervention programs and for evaluating the effects of curriculum change.

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