

# In search of key drivers for success in first year engineering courses

Jonathan Leaver<sup>a</sup>; Achela Fernando<sup>b</sup>  
*Unitec Institute of Technology<sup>a</sup>, Griffith University<sup>b</sup>*  
*Corresponding Author E mail: jleaver@unitec.ac.nz*

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## Structured abstract

### BACKGROUND

In 2010 and 2011 staff at Unitec Institute of Technology (Unitec) became increasingly concerned at the declining success rate of students in undergraduate Diploma level engineering courses. Unitec is the largest provider of technician and technologist level engineering education in New Zealand with over 340 full time equivalent students enrolled in either the two year New Zealand Diploma in Engineering (Civil) or the three year Bachelor of Engineering Technology (Civil). In order to identify key drivers to student success a study of 73 classes incorporating 95 courses offered in 2010 and 2011 across a range of civil engineering subjects was undertaken to identify the causes for the declining success rate and implement systems to address the issue.

### PURPOSE

The purpose of this study is to identify key drivers for success for first year students studying in the New Zealand Diploma in Engineering (Civil). The study focused on this group as they have the lowest success rates but are the most important single source of students with most of them staircasing into the Degree. The findings of this study are to be used to bring in changes to the course delivery in a way that the student retention, course completion and overall student satisfaction is improved.

### DESIGN/METHOD

In this study 95 engineering courses offered over an 18 month period were examined. Each course was classified according to three criteria. These are firstly the proportion of mathematical content in the course; secondly class size; and finally the percentage of degree and diploma students in each class. Success rates were then analysed both by course level and by programme to determine course content based key drivers.

### RESULTS

The study found that successful completion rates for first year (Level 4) Diploma students declined from 54% to 47% from 2010 to 2011 while those in the Degree (Level 5) rose marginally from 67% to 69%. For students who completed at least one assessment individual course success rates were as low as 38% in the Diploma and 50% in the Degree. Student dropout rates nearly halved after the first year of study in both the Degree and the Diploma from 17% and 21% respectively to 8% and 12%. However success rates were persistently low in both the Degree and Diploma with the overall success rate in the Degree ranging from 68% at Level 5 to 88% at Level 7 while in the Diploma success rates ranged from 51% at Level 4 to 76% at Level 6. Success rates showed no dependence on class size, mathematical content or the mix of degree and diploma students in a single class.

### CONCLUSIONS

An analysis of success rates in the three year civil engineering degree and two year civil engineering diploma shows that there is no significant dependency of success rate on either class size, mathematical content of the course, or the percentage mix of degree and diploma students in combined classes. Students' ability to make the transition from a directed learning environment at high school to a self-directed learning environment at Unitec is considered to be the most significant factor. We propose pre-semester credit-bearing introductory block course(s) in engineering fundamentals for first year students to assess and develop self-directed learning skills.

### KEYWORDS

Success, Key Drivers, Self-directed Learning.

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## Introduction

New Zealand is a South Pacific nation consisting of two main islands and a population of 4.3 million. The government invests about US\$760 per capita annually in tertiary education (MoE, 2010).

This investment underpins two of the six main goals of the current government. These are firstly to support innovation and business and secondly to ensure New Zealand has the skills it needs (MoE, 2010).

To support an innovation led economy the Institution of Professional Engineers of New Zealand (IPENZ) estimates that an annual increase in engineering graduates is needed of up to 233% on 2008 numbers from two year technician diplomas (Level 6) and three year technologist degrees (Level 7) (DoL, 2008). In order to maximise the value of investment the New Zealand government is progressively redirecting funding for tertiary education towards a focus on outputs (course completions) rather than inputs (student enrolments) (MoE, 2010). This in turn has called for a renewed focus at Unitec in raising success in engineering courses.

In seeking to improve success and retention it is important to have a clear vision of the graduate profile and knowledge of significant generic factors for success. In the context of this paper, student success is defined as a pass in a course that the student is enrolled in which essentially means meeting the thresholds for both coursework and final examination for the course.

Many factors contribute to the success of students. Students who develop deep learning skills and have a meaning-oriented approach have better success than students who have a reproduction-oriented approach (Tynjälä, Salminen, Sutela, Nuutinen, & Pitkänen, 2005). The grade point average of students entering the first year of study is a significant factor in determining success but non-cognitive factors can also have an important influence (French, Immekus., & Oakes, 2005). Student drive and optimism enhance success by facilitating the effective use of cognition (Nonis, Hudson, Philhours, & Teng, 2005) The level of optimism and success is also influenced by the personality of the teacher and pedagogy (Nonis et al., 2005). Students with high success rates have lower verbal skills than mathematical skills (Zhang, Anderson, Ohland, & Thorndyke, 2004). This is important if curricula move to include more "soft" courses in areas such as ethics, management and law where the exercising of these skills becomes a greater challenge for students. Students do not necessarily improve their success with the allocation of a greater number of tutorial hours (Sunthonkanokpong, 2011). Success must also be kept in the context that the focus of engineering education over the next decade is in producing graduates with strong problem solving skills who can think strategically within a global context (Sunthonkanokpong, 2011).

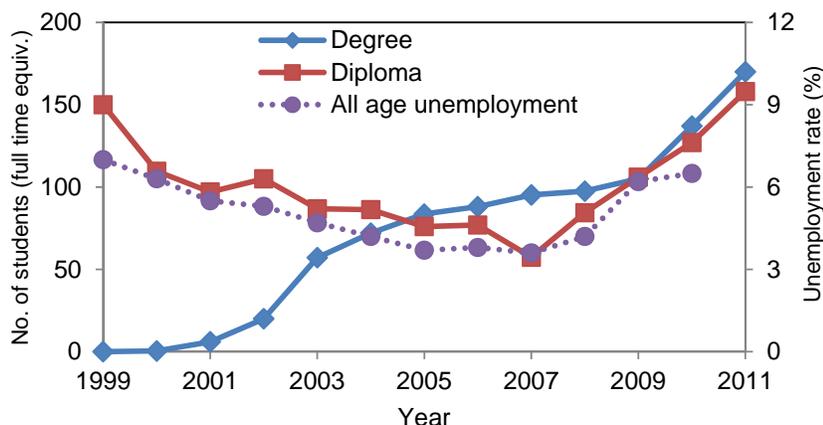
## Purpose

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## Background

Unitec offers two main civil engineering programmes. These are firstly the New Zealand Diploma in Engineering (Civil) that has international recognition under the Dublin Accord for engineering technician diplomas and secondly the Bachelor of Engineering Technology (Civil) that is recognised under the Sydney Accord for three year engineering technologist degrees. These programmes have experienced strong growth with a 24% increase in student numbers from 2010 to 2011. As shown in Fig. 1 this increase is closely related to the

unemployment rate that has risen from 3.6% in 2007 to 6.5% in 2010. The annual number of student enrolments in the Diploma for the period 1999 to 2010 correlates to the unemployment rate with a correlation coefficient of 0.934.



**Figure 1: Comparison of student enrolments with the all age unemployment rate**

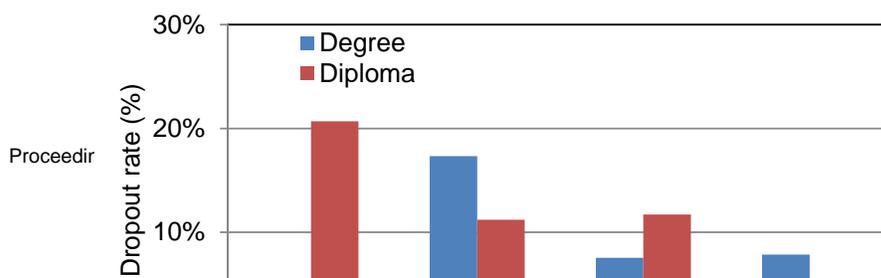
One of Unitec's strengths as a tertiary institute lies in providing academic staircases for students who may have natural ability but have underperformed at high school. This is achieved through the packaging and delivery of course material that is prerequisite to entry to the Diploma in a one-year Certificate in Foundation Studies. Students completing the Diploma may also staircase into the Degree and complete it with another 18 months of study. In 2010, approximately 30% of 180 equivalent full time students (EFTS) in the Diploma staircased into the Degree that contained 160 EFTS. Given the significant portion of Diploma students that transfer to the Degree, maximising student success and retention in the Diploma, particularly in the first year, is an important factor in increasing graduate numbers in the Degree.

Table 1 shows that success rates for first year (Level 4) Diploma students declined from 54% to 47% from 2010 to 2011 while those in the Degree (Level 5) rose marginally from 67% to 69%.

**Table 1: Variation in success rate with course level**

	Course Level	Year	
		2010	2011
Diploma	4	54.4	46.9
	5	69.7	71.8
	6	77.5	72.0
Degree	5	66.6	69.4
	6	76.9	83.3
	7	84.5	92.8

As shown in Fig.2 the highest dropout rate of 21% is for first year (Level 4) courses of the Diploma students who enrolled but did not complete compulsory assessments. This rate reduces to about 12% for Diploma courses at Levels 5 and 6. This trend is repeated in the Degree with a dropout rate of 17% in first year (Level 5) courses reducing to 8% at Levels 6 and 7.



**Figure 2: Variation in dropout rate with course Level**

Students in the Diploma average only 79% of a full academic work load. Most Degree students study full time as students and average 90% of a full load. A full academic work load is 60 credits in a 13-week semester.

## Methodology

With student numbers rapidly increasing one of the several initiatives undertaken by the Department of Civil Engineering to improve success and retention rates whilst maintaining robust academic rigour was to undertake a study of 95 courses offered in 73 classes delivered to students over an 18 month period commencing in 2010. Each course was classified according to three criteria. These are firstly the proportion of mathematical content; secondly class size; and finally the percentage of degree and diploma students. Success rates were then analysed both by course level and by programme to determine course content based key drivers. The mathematical content of each of the 73 courses was qualitatively rated as low, medium or high based on a review of each course descriptor.

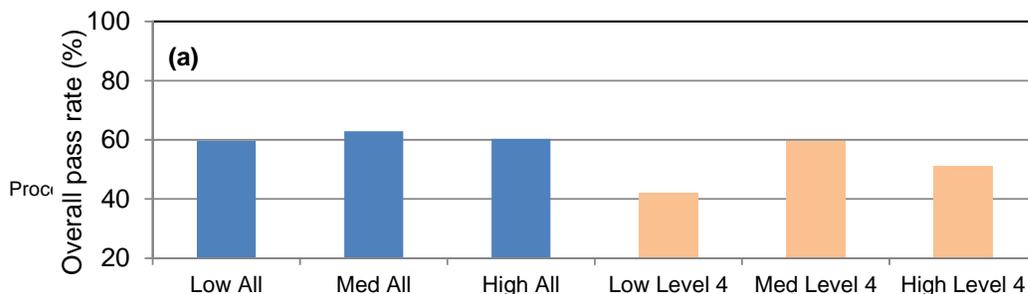
The rationale for the methodology relating to mathematical content was based on the fact that mathematics forms the basis for much of applied engineering theory and therefore low success may be triggered by an inability to apply mathematical theory in practice.

Correlating success with class mixes of Diploma and Degree students was considered important as the mode of delivery has significant implications for staff resourcing. Diploma and Degree students taking courses with similar content are sometimes taught in the same class although the two cohorts may have different assignments and may be taught in separate classes for a small proportion of the time. The method also included clarifying what effect the influence of students from two programmes would have, if any, on success rates in the two programmes.

Class size also has an important effect on staff resources required for delivery and hence the success rates in the 95 courses were examined to see if they were correlated with class size.

## Results

Fig. 3 shows the variation in success rate with mathematical content of courses for 2010 and 2011 in both the Diploma (Fig. 3a) and the Degree (Fig. 3b). In the Degree the average success for "All" courses was 77% but for first year (Level 5) courses this dropped to 66%. The success rates in the Degree vary by less than 2% for high, medium and low mathematical content. In the Diploma (Fig. 3a) the average success for "All" courses was 61% but for first year (Level 4) courses this dropped to an average of 51%.



(b)

Figure 3: Variation in pass rate with level of mathematics content: (a) Diploma (b) Degree

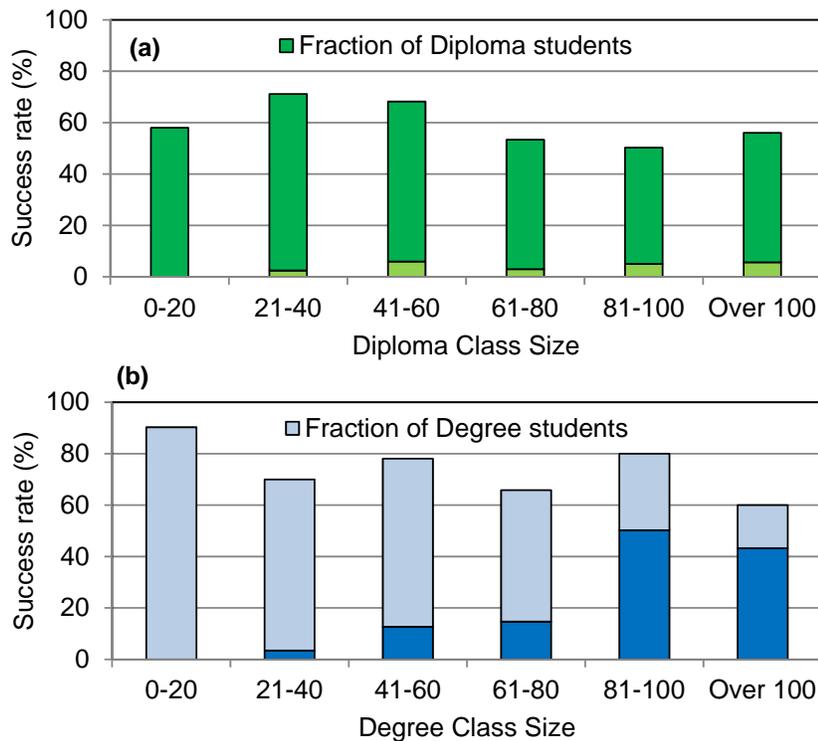


Figure 1: Variation in success rate with class size (a) Diploma dominated classes (b) Degree dominated classes

The success rates in the Diploma vary by less than 2% for all courses for high, medium and low mathematical content. However for first year (Level 4) courses success rates range from 42% for low mathematical content courses to 59% for medium mathematical content. The difference between medium and high mathematical content is smaller at 8%.

Fig. 4 shows the success rates for classes of different sizes and with differing proportions of Diploma and Degree students. The average class sizes in the Diploma and Degree were 58 and 46 respectively. In Fig. 4(a) the proportion of Degree students in Diploma classes is represented by the proportion of light green in the column and is less than 10% of the total. However the proportion of Diploma students in Degree classes represented by the proportion of dark blue in the column is as high as 63% for classes with 81-100 students. Success rates in Diploma classes (Fig. 4a) vary from 60% for classes over 100 students to 71% for classes with 21-40 students. Success rates in Degree classes (Fig. 4b) vary from 45% for classes of 81-100 students to 71% for classes of 21-40 students.

## Discussion

Success rates in both the Degree and Diploma were found to be independent of mathematical content (Fig.3). The Degree courses showed only 2% variation both at Level 5 and for "All" courses. However Diploma courses showed a variation at Level 5 of 17%. This large variation may be due to the fact that about 10% of Diploma students at Level 4 do not have English as a first language. This in turn may result in low pass rates for these students in courses that have low mathematical content but high grammatical content.

Success rates were also found to be independent of the ratio of Diploma to Degree students in any particular class. While the highest success rates in both the Diploma and Degree were in classes with less than 3% of students from another programme the next highest success rates were in classes with the highest proportions of students from another programme at 6% and 50% respectively.

Success rates in this study also appear to be independent of class size. The literature presents a mixed range of outcomes of the effect of class size on student success. Pascarella & Terenzini (2005) and Williams, Cook, Quinn, Jensen & Randall (1985) conclude class size does not necessarily mean lower success whereas McKeachie (1999) notes that class size may be the most prominent environmental factor in determining student success.

This study helps to refute the commonly and strongly held belief, sometimes through anecdotal evidence, that the mathematical content, mix of students, and class sizes are the main drivers of student success in a course. . Based on the results of this study and upon closer scrutiny and experience of the lecturers involved in direct consultation of student matters, we conclude that the most likely factor is the ability of the student to engage in self-directed learning. To test this hypothesis we propose a further longitudinal study of the success of students based on age, academic background and pedagogy. As immediate steps are needed to improve the performance of first year (Level 4) Diploma students we propose comprehensive pre-entry capability testing of applicants for the Diploma along with the development of a pre-entry civil engineering (Level 3) certificate. The certificate courses proposed would typically include Materials, Geology, Technical Literacy, Mechanics (structural and fluid), and Mathematics. The key goals of the course are to encourage student collegiality, embed fundamental engineering concepts and jargon let the students gain experience in self-directed learning, and instill familiarity with quantitative testing processes.

## Conclusion

An analysis of success rates in the three year civil engineering degree and two year civil engineering diploma at Unitec Institute of Technology shows that there is no significant dependency of success rate on either class size, mathematical content of the course, or the percentage mix of degree and diploma students in combined classes. Students' ability to make the transition from a directed learning environment at high school to a self-directed learning environment at Unitec is considered to be the most significant factor. We propose pre-semester introductory block course(s) in engineering fundamentals for first year students to assess and develop self-directed learning skills. It is also recommended that monitoring of these statistics is continued on a long term basis to identify the differences, if any, achieved as a result of the alterations made to course delivery.

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