Statistical analysis of correlation between students' personal characteristics and academic success in Engineering Mechanics course

Saeed, Shaeri[a]; Hong, Guan[a] and Simon, Howell[b].
School of Engineering, Griffith University[a], Griffith Science, Griffith University[b]
Corresponding Author Email: s.shaeri@griffith.edu.au

Structured Abstract

BACKGROUND
Understanding the factors which lead to student success or failure has long been an important matter for educators. Researchers like Zimmer et al. (1996) have focused on a particular science course to find the factors which lead to success, whereas others like Tynjälä et al. (2005) have examined an entire engineering program or degree to investigate the reasons behind students' performance. Although a number of factors have been identified by different scholars such as Cahan et al. (1989), there are still many aspects which have not yet been explored/examined.

PURPOSE
This research has aimed to focus on a particular engineering course to enable a better investigation tailored to engineering students. In this regard, students of two Engineering Mechanics classes (the 2012 and 2013 academic years) have been chosen at Griffith University and their personal characteristics have been explored to determine key factors leading to a satisfactory final mark in the mentioned course. The results would allow course convenors to more quickly identify vulnerable students.

DESIGN/METHOD
The parameters which have already been investigated by researchers are very broad. However, based on the available resources for this study and also considering the most important and effective parameters (inferred from Cahan et al. (1989) and Hoskins et al. (1997)), the following factors have been selected for detailed analysis: gender, age, first language, study program, prior grade point average (GPA) and overall positions (OP). Simple statistical analyses have been conducted for each of these parameters in light of the students' final mark. In addition, the correlation between scalar parameters (such as age) and final mark has also been observed.

RESULTS
Simple descriptive analysis has shown that there are no major differences between the 2012 and 2013 cohorts. The maximum, minimum and average marks for these classes were quite close. In particular, younger students achieved both the highest and lowest marks. Age did not affect the performance of mature students who were more evenly distributed in the middle range of results. Likewise, those from non-English speaking backgrounds were reasonably competitive with the others. More interestingly, no major difference was found between genders, although Hoskins et al. (1997) and Diaz (2003) both argued that there are differences in performance based on gender. Finally, the prior GPA and OP have shown a significant contribution to a better final mark.

CONCLUSIONS
The factors studied in this research have highlighted the important parameters for students' success. These should be noticed in the earliest stages of the semester to identify at-risk students to help them avoid becoming student-in-need later in the semester.

KEYWORDS
Engineering Mechanics, Students' Personal Characteristics, Academic Success

Introduction

Evaluation of students' success, with a view to enhancing their outcomes, has yet been studied extensively to identify relationships between students' different personal characteristics and academic environment in particular courses (in Engineering: Chen et al., 2013; in Science: Zimmer et al., 1996 and Mlambo, 2011) or full programs (in Engineering: Leavera et al., 2013; Tynjälä et al., 2005 and French et al., 2005; in Science: Hoskinset al., 1997; in Social Science: Newman-Ford et al., 2009). Many factors such as learning preferences and style, previous schooling and entry qualifications, class attendance, student's personality like age, intelligence and aptitude, family income and parents' education contribute to students' performance (Cahan et al., 1989; Hoskins et al., 1997). However, for engineering courses, there are still a number of unknown factors as well as interdependent parameters which need further investigation.

This study investigates some of the mentioned factors which lead to academic success in an Engineering Mechanics (EM) course at Griffith University. EM is one of the core courses in the engineering program which is taken by all first year undergraduate students. However, this course is also available as an elective for non-engineering students. Students' personal data for two classes in 2012 and 2013 including gender, age, first language, study program, grade point average (GPA) for the previous semester(s), overall positions (OP) for tertiary entrance and final mark for EM course were collected from university records (PSP, 2014) for extensive statistical analysis. The significance of the chosen parameters were derived and discussed in the following sections.

Database overview

To identify the students' personal characteristics which may contribute to success in a course, a thorough investigation of the literature (Leavera et al., 2013; Newman-Ford et al., 2009; Mlambo, 2011; Tynjälä et al., 2005; French et al., 2005; Zimmer et al., 1996) has been performed and a number of parameters were selected for data retrieval from the main database. Some parameters such as citizenship, place of birth and study load were rejected in the earlier study stages due to insufficient relevance. Consequently, gender, age, first language, study program, prior GPA and OP were chosen and are discussed hereafter.

Gender

One of the main classifiers of the student cohort is gender (Newman-Ford et al., 2009). Difference in the performance of males and females is still highly debatable depending on the subject matter (Haist et al., 2000). Many researchers believe that males outperform females (Hoskins et al., 1997); some believe the reverse (Diaz, 2003), and others see no difference between them (Kantartzi et al., 2010).

Age

Age appears to be a much more important factor than gender in contributing to success (Cahan et al., 1989; Zimmer et al., 1996). Many researchers like Mlambo (2011) and Haist et al. (2000) have all found age to be a challenging parameter and Richardson (1994) found that mature age students would not be at a disadvantage. For ease of analysis, the age was grouped as shown in Table 1.

First language

Language has been recognized to be the most significant barrier for international students (Chen et al., 2013). In addition, international students or those with non-English backgrounds have difficulty in adapting to the western learning culture. There were 53 different languages spoken in this two student cohorts which were divided into five language groups (Table 2).

The English speaking group is the first and largest group; the second and next largest group includes different Chinese dialects, and other languages are classified based on their geographical location.

Grade point average

The grade point average (GPA) for the previous semester(s) was also obtained for analysis. French et al. (2005) mentioned that GPA is a significant classifier of performance. In this research, GPA has a range between zero and seven and was grouped as shown in Table 4. GPA was not available for a small percentage of students.

Study program

The title of the student's degree programs were categorized (Table 3) to identify if there is any connection between the student's success in the course and the program they are enrolled in.

Overall positions

Other possible indicator of the scientific strength of students could be the marks they obtained during their secondary school studies (Cahan et al. 1989). In Queensland, Australia, OP (Overall Positions) is widely used as a tertiary entrance rank for selection into universities (OP, 2014). Like similar systems used throughout the rest of Australia, OP shows how well a student has performed in their senior secondary studies, compared to all other OP-eligible students. OP is an integer number from 1 to 25, where 1 is the best and 25 is the worst. Here, OPs were clustered in 6 groups (Table 5). OP was unavailable for students who completed their secondary studies outside Queensland.

Table 1: Age Groups

Group	AG1	AG2	AG3	AG4	AG5
Age Limit	=<19	20-21	22-25	26-30	>=31

Table 2: First Language Groups

Group	**First Languages**
LG1	English
LG2	Chinese (Including Mandarin, Cantonese and others)
LG3	Arabic, Bengali, Dari, Filipino, Gujarati, Hindi, Indonesian, Japanese, Korean, Malay, Maori, Nepali, Pashto, Persian, Punjabi, Thai, Turkmen, Urdu, Vietnamese
LG4	Bosnian, Dutch, Flemish, French, German, Greek, Hungarian, Italian, Norwegian, Polish, Portuguese, Romanian, Russian, Serbian, Spanish
LG5	Afrikaans, Akan, Burmese, Hazaraghi, Khmer, Kiswahili, Kurdish, Madi, Malayalam, Oceanic Pidgins & Creoles, Sinhalese, Tamil, Telugu, Tongan, Other Non-English

Table 3: Program Groups

Group	**Program Titles**
PG1	BEng, BEng with Advanced Studies
PG2	BEng (Civil Eng)/BBus (Management), BEng/BSc, BEng/BIT(Information Technology)
PG3	BEngTech, B Industrial Design
PG4	B. Science, B. Science Ecology & Conservation Biology, B. Marine Science, B. Biomolecular Science
PG5	B. Psychological Science, B. Commerce

Final marks

A final mark is achieved by every student as a result of different assessment items for the course including assignments, laboratory reports, and exams, with 50 out of 100 being the pass mark. For simplicity, final marks were also categorized in to 7 different groups (Table 6).

Result of analyses

This research examines two cohorts of EM students in 2012 and 2013. Analyses of the collected data, as well as the final marks obtained by students, revealed some facts as well as relationships and correlations between different parameters, which are discussed here.

Simple descriptive statistics

The numbers of students who enrolled in the courses and received a final mark were 285 and 287 for 2012 and 2013 respectively. In the 2012 class, 253 (89%) students had an existing GPA, and 176 (62%) had an OP. In addition, in the 2013 class, 260 (91%) students had a GPA, and 184 (64%) had an OP. The simple statistics in Table 7 show that the minimum, maximum, average, standard deviation and variance for the scalar parameters, i.e. OP, GPA, age and final mark, are almost the same. Hence, the results from both classes can be used to explain the conclusions. Frequency and percentage of occurrence for these scalars can also be found in Figure 1.

Table 4: GPA Groups

Group	GPA1	GPA2	GPA3	GPA4	GPA5	GPA6
GPA	<=2.0	2.0-3.5	3.6-4.0	4.1-5.0	5.1-6.0	6.1-7.0

Table 5: OP Groups

Group	OP1	OP2	OP3	OP4	OP5	OP6
OP	<=4	5-7	8-10	11-13	14-16	17<

Table 6: Final Mark Groups

Group	FM1	FM2	FM3	FM4	FM5	FM6	FM7
Final Mark	=<24	25-44	45-49	50-64	65-74	75-84	85=<

Table 7: Descriptive Statistics

		Minimum	**Maximum**	**Average**	**Variance**	**Standard deviation**
OP	2012	2	25	9.9	14.2	3.8
	2013	2	24	9.9	18.8	4.3
GPA	2012	1.5	7.0	4.4	1.2	1.1
	2013	1.9	7.0	4.9	1.1	1.1
Age	2012	17	50	19.2	12.4	3.5
	2013	17	45	19.4	18.3	4.3
Final Mark	2012	2	96	58.1	322.1	17.9
	2013	3	95	61.1	402.5	20.1

With an overall view of the final marks, the success rate (passing the course with a final mark more than 50) was 82% in 2012 and 73% in 2013. In the 2012 class, for the lowest mark group (FM1), the lowest GPA was 1.5 and the best OP was 4. For the highest mark group (FM7), the lowest GPA was 3.42 and the best OP was 2. In addition, in the 2013 class, for the lowest mark group, the lowest GPA was 2.5 and the best OP was 7. For the highest mark group, the lowest GPA was 3.33 and the best OP was 2.

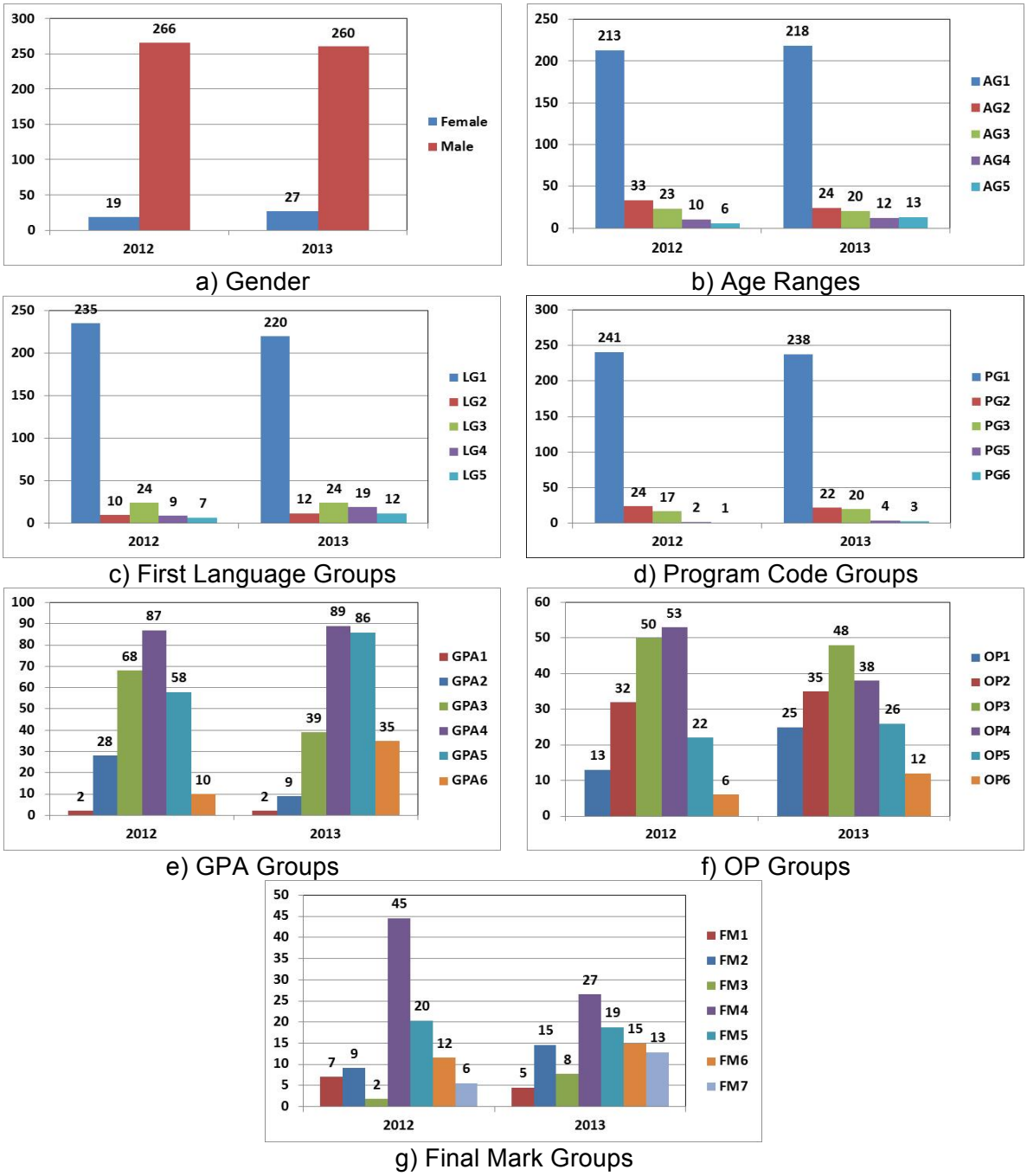

Figure 1: Frequency occurrence of parameters retrieved from the database (PSP, 2014)

Age

In the 2012 class, about 75% of the entire class were in the youngest group (AG1), 11% of whom did not have English as their first language. Both the highest and lowest marks fall

within AG1, although high marks were found in all groups irrespective of age. The four youngest females of the total 13 females failed the course whereas the oldest female passed the course. 29 of the youngest males also failed the course. However, 93 of them achieved a result in the FM4 group. All the 6 male students in the age group of older than 31 (AG5) passed the course. The oldest student (50 years old) was also grouped in the FM5 group. This could be in accordance to what Richardson (1994) concluded that “the academic performance of mature students is as good, if not better”.

In the 2013 class, just above 76% were in the youngest group (AG1), 19% of whom were in a non-English speaking group. Regarding females, 21 students were in AG1, of which 5 students failed the course. Both of the oldest females passed the course. For the 260 male students, 58 of the youngest males failed the course, but 50 of them achieved a result in the FM4 group. There were 11 male students in AG5, of which 3 failed while the oldest student (45 years old) passed the course.

GPA

In the 2012 class, the best GPA (7.0) was achieved by two students. No females were in the GPA1 and GPA3 groups, while there was equal number of females in the GPA4 and GPA5 groups (altogether 66%). One female student (in the GPA2 group) and one male student (in the GPA1 group), both had the lowest marks. In total, the students who failed were mostly found in the GPA3 and GPA4 groups. In the 2013 class, the best GPA was achieved by several students, regardless of being in a particular group of final marks. No females were in the GPA1 group, and the majority were in GPA4 and GPA5 (altogether 60%). It was also noticed that in each GPA group there was at least one female student who failed. Overall, 21% of all students who failed were also in the GPA4 and GPA5 groups.

OP

In the 2012 class, there were no females in the OP5 and OP6 groups, while the same numbers were in OP3 and OP4 (altogether 84%). One female was in the lowest mark group, although she was in the OP4 group. This was found for some males as well; since there was one student in the lowest mark group who belonged to the weakest OP group. Generally, the common OP groups were OP3 and OP4 with 11.4% of students who failed being in those groups. Interestingly, a student with an OP of 25 successfully passed the course.

In the 2013 class, there were no females in the OP1 and OP6 groups, while equal numbers of females were in the OP2 and OP4 groups (in total 82%). One female student was in the highest mark group although she belonged to the weakest OP group. For males, one student failed the course even though he was in the OP1 group, and 10 males with the highest marks had the weakest OPs. Other frequent OP groups were OP3 and OP4. 20.1% of the failed students were in the OP3 and OP5 groups.

Study program

In the 2012 class, all 19 female students were enrolled in the PG1 and PG2 groups. Males however, were also in PG3 in addition to PG1 and PG2. In the 2013 class, 10 of the 27 females in this class were in the PG1 group. It was almost the same for males. 191 males passed the course, 91% of whom belonged to the PG1 and PG2 groups.

First language

In the 2012 class, almost all female students were in the LG1 group, except for two in LG3. LG1 was also the most commonly spoken first language for males (235 students). In total, 4 of the 51 students who failed did not have English as their first language. In the 2013 class, 20 female and 220 male students were in the LG1 group. LG3 (24 students) and LG4 (19 students) were the other common first language groups for males. 12 out of 77 students who failed the course did not have English as their first language.

Final mark

In the 2012 class, males received both the highest (96) and lowest (2) marks, while the lowest female mark was 17. The highest and lowest marks belonged to the LG1 language group. The lowest mark was for the PG3 program group and the highest for PG1. In the 2013 class, a female received the highest marks (95), while a male had the lowest marks (3). The highest and lowest marks were found in LG1. The lowest mark was for the PG3 and PG1 program groups and the highest was for PG1.

Analysis of variance and correlation

An analysis of variance (ANOVA F-test) and Person's correlation test have been conducted for the scalar parameters. Under the level of selected significance (1%), Table 8 shows that all the significant figures are non-zero and corresponded to a rather large F figure. This suggests the rejection of alternative hypotheses and acceptance of the null hypothesizes that there was a strong relationship between age, OP and GPA with the final marks. Accordingly, Table 9 denotes the similar degree of strong relationship and correlation based on Pearson's correlation test. The negative Pearson factor for OP is the result of lower OPs being better.

Table 8: Result of ANOVA test against Final Marks for the 2012 and 2013 classes

			Sum of Squares	df	Mean Square	F	Sig.
2012	GPA	Between Groups	296.6	247	1.20	0.88	0.66
		Within Groups	6.8	5	1.37		
		Total	303.5	252			
	OP	Between Groups	2476.9	174	14.23	7.12	0.29
		Within Groups	2.0	1	2.00		
		Total	2478.9	175			
	Age	Between Groups	3424.0	278	12.32	0.94	0.61
		Within Groups	78.5	6	13.08		
		Total	3502.5	284			
2013	GPA	Between Groups	282.7	253	1.12	1.56	0.30
		Within Groups	4.3	6	0.72		
		Total	287.0	259			
	OP	Between Groups	3437.1	180	19.10	19.10	0.02
		Within Groups	3.0	3	1.00		
		Total	3440.1	183			
	Age	Between Groups	5154.4	279	18.47	1.74	0.22
		Within Groups	74.5	7	10.64		
		Total	5228.9	286			

Table 9: Result of Pearson's correlation test to Final Marks for the 2012 and 2013 classes

		GPA	OP	Age
2012	Pearson Correlation	0.57	-0.30	0.08
	Sig. (2-tailed)	0.0	0.0	0.20
2013	Pearson Correlation	0.10	-0.29	0.07
	Sig. (2-tailed)	0.10	0.00	0.23

Discussion and conclusions

Factors influencing success for university students have been widely examined. Some scholars were interested in a particular subject and course whereas many others have researched specific programs or degrees. To date, there have been few studies specifically examining science and engineering students. Therefore, individual analysis for a particular course at specific universities is still essential. The authors emphasize that the statements and the outcomes in this paper are limited to the student cohorts in this study and are not able to be extrapolated outside the two selected groups of students.

In this research, two cohorts of Engineering Mechanics students at Griffith University have been chosen to identify key factors of their personal characteristics that could contribute to their success. Extensive statistical analyses have been conducted on factors like gender, age, first language, study program, prior GPA and OP, and the final marks for the course. The results of ANOVA F-test and Pearson' correlation test showed a strong to very strong positive correlation between age and final mark and a strong negative correlation between the final mark and the OP rank. Similar to Kantartzi et al. (2010), there were no significant indicators for one gender outperforming the other. Moreover, when looking at some of the individual records (e.g. the oldest female students), it was evident that maturity and gender did not necessarily result in failure or lower results, which matches Richardson's (1994) findings. Overall, the majority of the students who failed were males under 19 years old.

With the extent of the current data set, we have not found any specific reason to explain the success or failure of students in different program groups. Although, the majority of students with high marks were enrolled in the Bachelor of Engineering program, the marks achieved by groups in other programs were not significantly higher or lower. Despite the belief of many researchers like Chen et al. (2013) that the language barrier could affect performance in a course, the majority of students in this cohort who failed (86%) had English as their first language. Hence, the influence of first language also did not show an effect.

One of the aspects that have not been investigated in this study is the amount of background knowledge of mathematics or physics that the students possess. This is likely to vary for the students, and may influence their success (Kavanagh et al., 2009; Burton et al., 2013; Klimovski et al., 2012). Further research could be implemented to find such important factors.

References

Burton, L. J., Albion, M., Shepherd, M., McBride, W., & Kavanagh, L. (2013). *Helping first year engineering students get set for success in their studies*. Proceedings of the Higher Education Research & Development Association Conference, Auckland, New Zealand.

Cahan, S. and N. Cohen (1989). Age versus schooling effects on intelligence. *Child Development*, 60, 1239-1249.

Chen, S. & Kavanagh, L. (2013). *Identification of issues faced by international students in first year project-based engineering classes*, In: Charles Lemckert, Graham Jenkins and Susan Lang-Lemckert, Proceedings of the 24th Annual Conference of the Australasian Association for Engineering Education: AAEE2013 Proceedings, Gold Coast, QLD, Australia, 8-11 December, 2013.

Diaz, A. L. (2003). Personal, family, and academic factors affecting low achievement in secondary schools. *Electronic Journal of Research in Educational Psychology and Psychopedagogy*, 1(1), 43–66.

French, B.F., Immekus., J.C., & Oakes, C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Eng. Edu*cation, Oct., 419-425.

Haist, S. A., Wilson, J. F., Elam, C. L., Blue, A. V., & Fosson, S. E. (2000). The effect of gender and age on medical school performance: An important interaction. *Advances in*

Health Sciences Education, 5(3), 197 – 205.

Hoskins, S. L., Newstead, S. E., & Dennis, I. (1997). Degree performance as a function of age, gender, prior qualifications and discipline studied. *Assessment & Evaluation in Higher Education*, 22(3), 317-328.

Kantartzi, S. K., Allen, S., Khalid, L., Robert, L. G. I. V. & Kassem, M. A. (2010), Study of Factors Affecting Students' Performance in Three Sci-Ence Classes: General Biology, Botany, and Microbiology at Fayetteville State University', *Atlas Journal of Science Education*, 1(1),13-18.

Kavanagh, L., O'Moore, L., & Samuelowicz, K. (2009). *Characterising the first year cohort knowledge*. Proceedings of the Australasian Association of Engineering Education conference, Adelaide, Australia.

Klimovski, D.; Cricenti, A. & O'Donoghue, P. (2012). *Improving engineering awareness of secondary school students*. Proceedings of the 23rd Australasian Association for Engineering Education Conference. Melbourne, Australia.

Leaver, J. & Fernandob, A. (2013). *In search of key drivers for success in first year engineering courses*, In: Charles Lemckert, Graham Jenkins and Susan Lang-Lemckert, Proceedings of the 24th Annual Conference of the Australasian Association for Engineering Education: AAEE2013 Proceedings, Gold Coast, QLD, Australia, 8-11 December, 2013.

Mlambo, V. (2011). An analysis of some factors affecting student academic performance in an introductory biochemistry course at the University of the West Indies. *Caribbean Teaching Scholar*, 1(2), 79–92.

Newman-Ford, L., Lloyd, S., & Thomas, S. (2009). An investigation in the effects of gender, prior academic achievement, place of residence, age and attendance on first-year undergraduate attainment. *Journal of Applied Research in Higher Education*, 1(1), 13–28.

OP (2014). Overall Positions, Queensland Studies Authority. November 2012. Retrieved July 01, 2014 for http://www.qsa.qld.edu.au/630.html,

PSP (2014), Planning and Statistical Portal, Griffith University, Retrieved July 01, 2014 from http://www.griffith.edu.au/planning-support/business-intelligence.

Richardson, J. T. E. (1994). Mature students in higher education: Academic performance and intellectual ability. *Higher Education*, 28(3), 373 – 386.

Tynjälä, P., Salminen, R. T., Sutela, T., Nuutinen, A., & Pitkänen, S. (2005). Factors related to study success in engineering education. *European J. of Eng. Education*, 30, 221-231.

Zimmer, J., & D. Fuller. (1996). *Factors affecting undergraduate performance in statistics: A Review of Literature*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Tuscaloosa, AL, November 1996).

Acknowledgements

The first author is grateful to Mr. R. H. A. Mohammadi for his assistance with the data analysis and statistical interpretation. The first author would also like to express sincere thanks to Ms. R. Barnes for her assistance in proofreading. The Authors wishes to acknowledge the Griffith University Office of Planning and Financial Services for provision of the data.

Copyright statement