International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 9, Issue 6, 2019

Exploring Relationship between Matriculation Performance and University Achievement – A Case Study of Graduating Mechanical Engineering Batch 2015

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This study aims to analyse correlation between student performance during matriculation studies and their yearly performance during undergraduate studies from their first to final year, including their achievement in design competency. A group of mechanical engineering students that graduated in 2015 was selected for this study. Their grade point average from matriculation and degree studies was compiled, together with their program objective achievements. Both graphical and statistical analysis were undertaken to formally compare and analyse their correlation. Results indicate no clear correlation between matriculation and academic performance in university for these mechanical engineering students, and that many underlying factors may contribute to variation in undergraduate performance. In addition, achievements of graduating students in engineering design competency are not influenced by their matriculation performance, indicating importance of their related teaching and learning experience during their university undergraduate program. This study may be applied to universities and pre-university institutions as a means to continuously monitor student performance and provide feedback on education quality.

Key words: *Undergraduate achievement, mechanical engineering, matriculation performance, design competency, program outcomes.*

Introduction

The Department of Mechanical and Materials Engineering in the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia (UKM), annually offers bachelor of engineering degree programs for mechanical engineering and manufacturing engineering. In the first two years, students from both degree programs undertake similar courses that cover fundamental engineering topics including engineering mathematics, basic fluid mechanics, basic thermodynamics, engineering design graphics, materials, engineering mechanics and programming. In their third and fourth (final) years, students from each degree program then enrol in courses that are tailored to either mechanical engineering or manufacturing engineering.

In their third year, mechanical engineering students in the department are exposed to more advanced topics in both fluid mechanics and thermodynamics, mechanical engineering design, control engineering and dynamic systems. They are also required to complete a 12-week industrial training or attachment with various engineering industry or organization outside of UKM. In the fourth or final year of their mechanical engineering degree program, students are required to complete their thesis and undertake several elective courses. Overall, mechanical engineering students are required to complete 173 credits of course work throughout their degree program (Fakulti Kejuruteraan dan Alam Bina, 2014).

Table 1: Program outcomes (PO) for mechanical engineering degree program

PO1	Ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialisation to the solution of complex mechanical / manufacturing engineering problems.
PO2	Ability to identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO3	Ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PO4	Ability to conduct investigation into complex problems using research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
PO5	Ability to create, select and apply appropriate techniques, resources, and modern

	engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.
PO6	Ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO7	Ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
PO8	Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO9	Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO10	Ability to function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
PO11	Ability to recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PO12	Ability to demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

In addition, a recent shift in higher education philosophy has placed more emphasis on students acquiring necessary competencies to potentially be successful engineers upon their graduation (Osipov et al., 2015; Dugarova et al., 2016; Board of Engineers Malaysia, 2012). Hence, outcome-based education (OBE) has been practiced in the faculty since 2006 (Mohd Nor, 2006), with students expected to achieve the 12 program outcomes (PO) outlined by the Board of Engineers Malaysia (Board of Engineers Malaysia, 2012). For the mechanical engineering degree program in the faculty, these outcomes or competencies are presented in Table 1 above.

Students enrolled in mechanical engineering degree program come from various entry programs, including Malaysia Higher School Certification (MHSC i.e. secondary form 6 students) and diploma programs, but the majority of students come from pre-university matriculation programs. Entry requirements into mechanical engineering degree programs require a minimum cumulative grade point average (CGPA) during matriculation studies, and often, students undertaking this degree program attain excellent CGPA during their matriculation. Although many students graduate in their fourth year of studies, brief inspection of their CGPA suggests larger variance in comparison to their matriculation CGPA.

Furthermore, previous analysis in the program has focused on student achievements in their technical application and analysing skills (PO1 and PO2) (see for example (Harun et al., 2016)), but limited attention has been given to their engineering design ability (PO3). With a recent need to engineer design solutions while considering health, safety, cultural, societal and environmental issues, this is an important competency for practicing engineers and represent an important attribute among employers (Zaharim et al., 2009; Yaron, 2017). Therefore, this investigation aims to formally explore and analyse relationship between matriculation performance and university performance of students undertaking mechanical engineering degree program, including their achievement in PO3 competency.

Methodology

In order to perform this study, a batch of mechanical engineering students who enrolled in the Faculty of Engineering and Built Environment, UKM, in the 2011/2012 session and graduated in 2015, was selected. A total of 30 students, all of whom graduated from their matriculation program, were employed in this study. Their matriculation CGPA and yearly degree CGPA was obtained and compiled from records in the Faculty of Engineering and Built Environment. Students CGPA in semester 1 or 2 in each year were used to represent their yearly CGPA. Further graphical analysis and linear regression were performed to analyse compiled data. From this, correlations between yearly performance were estimated to establish possible trends between their yearly performance.

Similarly, corresponding achievement in PO3 competency of these students were compiled from the records in the Department of Mechanical and Materials Engineering in the faculty. Achievements of each program outcome for every student were measured from their relevant contributing courses and were marked out of 100. In order to fairly compare or correlate this PO3 marks with CGPA, student CGPA were normalised out of 100, where a CGPA of 4.0 corresponds to 100, while a CGPA of 0.0 corresponds to a mark of 0. A linear regression and correlation analysis were performed to analyse potential trends in data.

Results and Discussion

CGPA Performance

CGPA of mechanical engineering students during their matriculation and degree studies that were used in this study are compiled in Table 2. Average CGPA and CGPA distribution for all 30 samples were calculated in each year. During their matriculation program, CGPA of students were distributed around an average of 3.82 and within ± 0.18 of this average. However, their CGPA performance seems to lower as they progress through their mechanical engineering degree programs, as indicated by their yearly CGPA average and distribution, i.e. 3.21 ± 0.73, 3.04 ± 0.78, 2.98 ± 1.11 and 3.05 ± 0.94 from year 1, 2, 3 and 4 respectively.

Figure 1 below summarizes the trend in CGPA for each sample from matriculation to their fourth year studies. Although all students obtained CGPA > 2.0 in their fourth year of studies (which is the minimum requirement to graduate), Figure 1 shows that CGPA during their degree program are lower from their matriculation studies and that their CGPA tend to lower as they progress through their degree program. Overall, CGPA of students during their mechanical engineering degree are highest in their first year and tend to progressively lower until their third year, before improvement is observed in their fourth year. This is also indicated in Table 2 below, where the average and distribution of CGPA among students in year 4 is higher than in year 3. We hypothesise that this may highlight or may be due to a number of factors. Firstly, mechanical engineering courses in year 1 comprise basic and introductory courses, which are generally easier as compared to advanced courses in year 2 and year 3. Secondly, in their fourth year, students may tend to perform better undertaking electives and thesis works, where limited number of students are enrolled in these courses and students may attain closer attention with their instructors or supervisors.

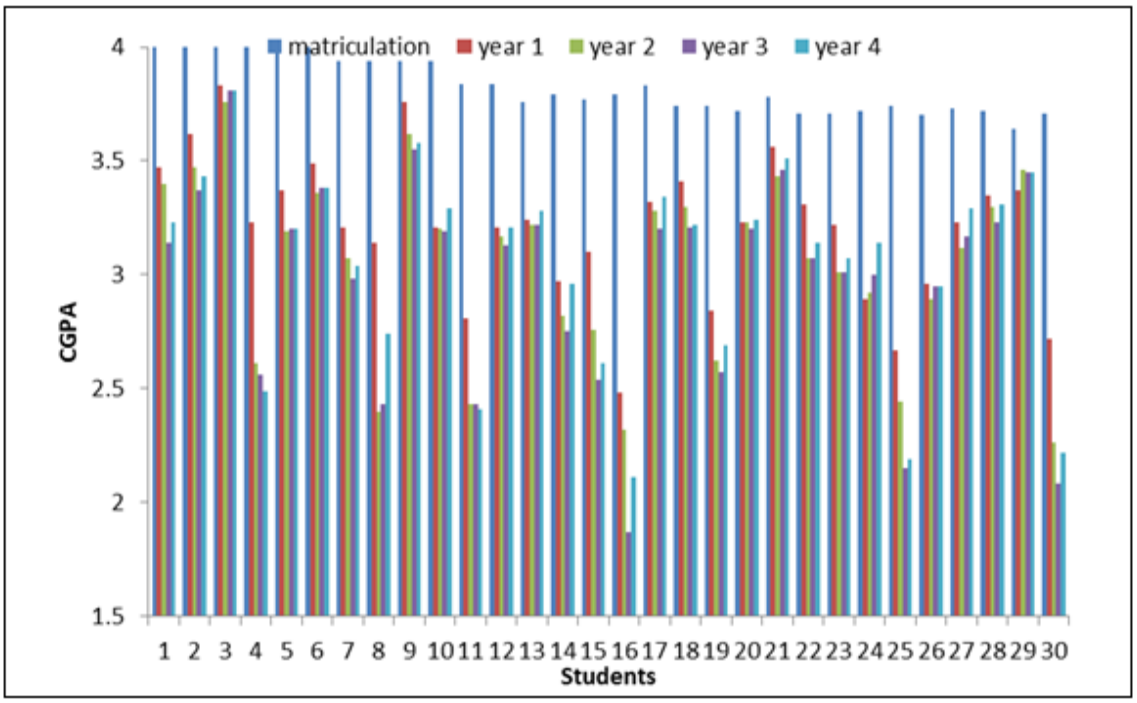
Table 2: Compiled CGPA of mechanical engineering students

Students	CGPA matric.	CGPA year 1	CGPA year 2	CGPA year 3	CGPA year 4
1	4.00	3.47	3.4	3.14	3.23
2	4.00	3.62	3.47	3.37	3.43
3	4.00	3.83	3.76	3.81	3.81
4	4.00	3.23	2.61	2.56	2.49
5	4.00	3.37	3.19	3.20	3.20
6	4.00	3.49	3.36	3.38	3.38
7	3.94	3.21	3.07	2.98	3.04
8	3.94	3.14	2.40	2.43	2.74
9	3.94	3.76	3.62	3.55	3.58
10	3.94	3.21	3.2	3.19	3.29
11	3.84	2.81	2.43	2.43	2.41
12	3.84	3.21	3.17	3.13	3.21
13	3.76	3.24	3.22	3.22	3.28
14	3.79	2.97	2.82	2.75	2.96
15	3.77	3.10	2.76	2.54	2.61
16	3.79	2.48	2.32	1.87	2.11
17	3.83	3.32	3.28	3.20	3.34
18	3.74	3.41	3.30	3.21	3.22
19	3.74	2.84	2.62	2.57	2.69
20	3.72	3.23	3.23	3.20	3.24
21	3.78	3.56	3.43	3.46	3.51
22	3.71	3.31	3.07	3.07	3.14
23	3.71	3.22	3.01	3.01	3.07
24	3.72	2.89	2.92	3.00	3.14
25	3.74	2.67	2.44	2.15	2.19
26	3.70	2.96	2.89	2.95	2.95
27	3.73	3.23	3.12	3.17	3.29
28	3.72	3.35	3.30	3.23	3.31
29	3.64	3.37	3.46	3.45	3.45
30	3.71	2.72	2.26	2.08	2.22
AVERAGE	3.82	3.21	3.04	2.98	3.05
MAX.	4.00	3.83	3.76	3.81	3.81
MIN.	3.64	2.48	2.26	1.87	2.11
(AVG.-MIN.)	$\pm$ 0.18	$\pm$ 0.73	$\pm$ 0.78	$\pm$ 1.11	$\pm$ 0.94
MEDIAN	3.785	3.23	3.145	3.135	3.205

STD. DEV.	0.118	0.314	0.404	0.461	0.433

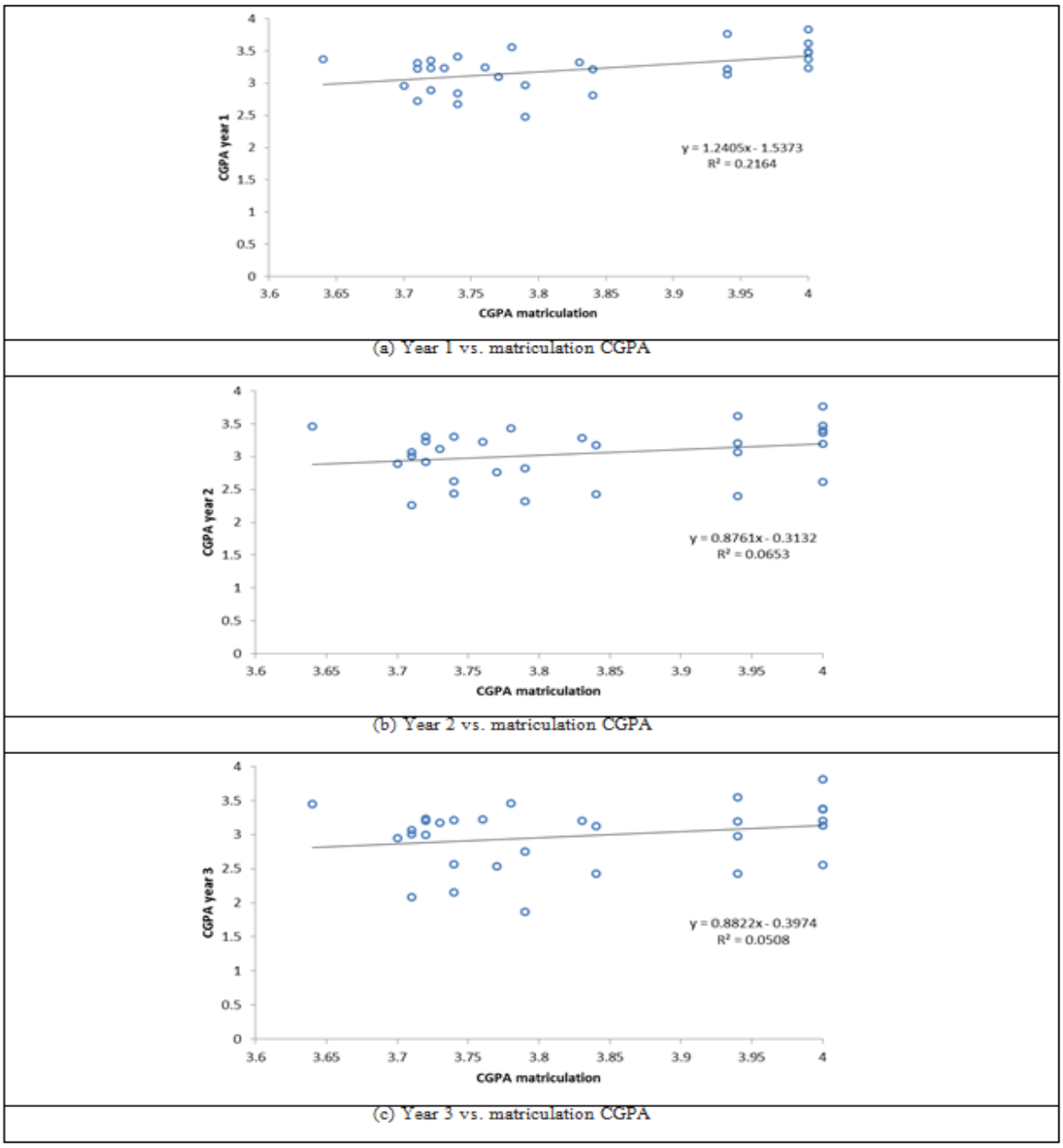
Although CGPA of students in their first year are highest among their yearly degree performance, Figure 1 indicates there is significant drop in year 1 CGPA compared to their matriculation performance. This may highlight a difference in course content between university and matriculation studies and perhaps more importantly, a difference in learning culture and/or discipline during university compared to matriculation. This is perhaps supported by previous studies indicating importance of academic self-discipline on first-year performance (Allen et al., 2008) and decline in academic performance when students experience changes in their environment and academic routines (Rose, 2016). Similarly, transitioning to higher education have often been reported as a challenging experience (Gale & Parker, 2014) and may lead to first-year dropping out. This drop in first year performance may exacerbate performance in later years, since first year courses are often basic courses that may influence understanding of later courses and that students may also risk undertaking too many courses in later years if students intend to re-enrol certain first year courses.

Figure 1. Comparison of CGPA from matriculation to degree studies



Linear regression analyses based on method of least squares were also performed to analyse possible relation between CGPA of students during matriculation and their yearly degree CGPA. These results are presented in Figure 2 below for all four years of their mechanical engineering degree studies.

Figure 2. Relationship between matriculation CGPA and degree CGPA



(a) Year 1 vs. matriculation CGPA

(b) Year 2 vs. matriculation CGPA

(c) Year 3 vs. matriculation CGPA

Results from analysis suggest low correlation between CGPA of students in their matriculation studies to CGPA obtained during their mechanical engineering degree studies. Figure 2 shows that the best correlation (R2 = 0.2164) is obtained between first year degree CGPA and corresponding matriculation CGPA. While in later years, R2 values dropped significantly (< 0.07) as CGPA distribution and deviation further increased. Although a positive slope (and positive correlation) in Figure 2(a) to (d) may suggest that students with higher matriculation CGPA tend to obtain higher CGPA during their degree program, this correlation may not be entirely reliable. As shown in Figure 2, there are students who

maintained excellent performance from matriculation to their mechanical engineering degree studies. There are also a number of students who did not obtain better matriculation CGPA compared to their colleagues, but obtained better CGPA during their degree studies and conversely, vice-versa. This finding seems to agree with previous studies from other departments which found no clear correlation between pre-university performance (either test or CGPA) with performance of certain courses in their investigation (Osman et al., 2014; Wan Zaki et al., 2014). Therefore, students are encouraged to adapt to appropriate learning culture in the university during their degree studies.

PO3 Relationships

Table 3 below presents achievement of program outcome PO3 (i.e. engineering design competency) of students in comparison to both their matriculation and final degree CGPA, which are normalised to per 100. Average and variance in PO3 achievement appears much closer to final degree CGPA compared to matriculation CGPA. This again suggests that matriculation performance may not necessarily correlate well to achievement in design competency during undergraduate studies.

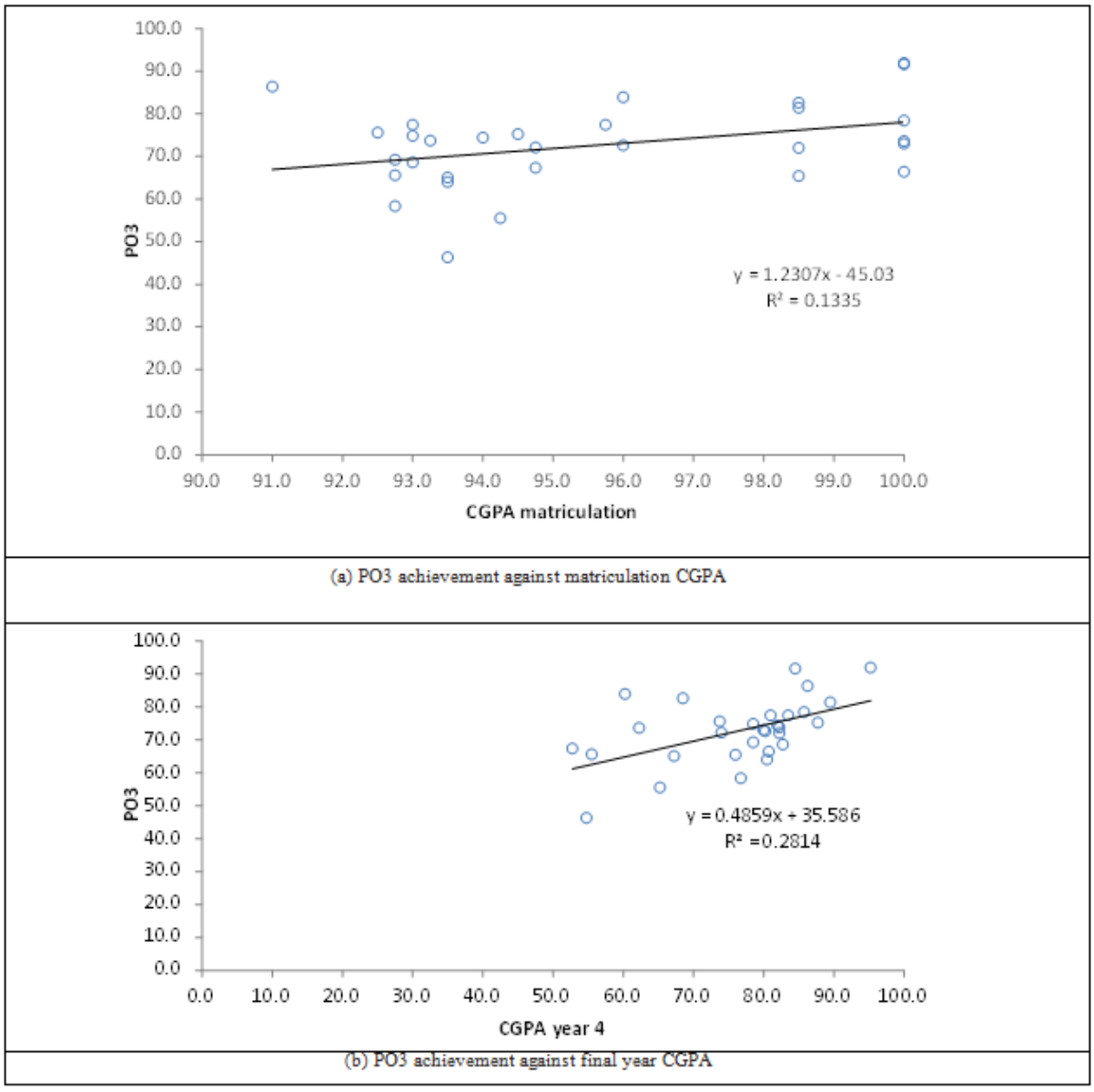
Table 3: Normalised CGPA against PO3 achievement

Students	CGPA matric.	CGPA year 4	PO3
1	100.00	80.75	66.4
2	100.00	85.75	78.4
3	100.00	95.25	91.9
4	100.00	62.25	73.6*
5	100.00	80.00	73.0
6	100.00	84.50	91.6
7	98.50	76.00	65.4
8	98.50	68.50	82.6
9	98.50	89.50	81.4
10	98.50	82.25	72.0
11	96.00	60.25	83.9*
12	96.00	80.25	72.6
13	94.00	82.00	74.4
14	94.75	74.00	72.1
15	94.25	65.25	55.5
16	94.75	52.75	67.3
17	95.75	83.50	77.4
18	93.50	80.50	64.0
19	93.50	67.25	65.0

20	93.00	81.00	77.4
21	94.50	87.75	75.2
22	92.75	78.50	69.2
23	92.75	76.75	58.3
24	93.00	78.50	74.8
25	93.50	54.75	46.3
26	92.50	73.75	75.6
27	93.25	82.25	73.7
28	93.00	82.75	68.6
29	91.00	86.25	86.3
30	92.75	55.50	65.6*
AVERAGE	95.62	76.28	72.65
MEDIAN	94.63	80.13	73.27
STD. DEV.	2.94	10.83	9.92

Figure 3 below better illustrates these results graphically. Positive correlation is shown between student PO3 achievement and their corresponding CGPA, indicating that students with higher CGPA tend to achieve better competency in PO3. In addition, the correlation coefficient (R) shows reasonable correlation between PO3 competency and final degree CGPA (i.e. R = 0.53 from Figure 3(b)), but a weak correlation between PO3 competency and matriculation CGPA (i.e. R = 0.37 from Figure 3(a)). Therefore, performance during matriculation studies does not necessarily influence performance in achieving engineering design competency during undergraduate program, and vice versa. In particular, the present study also indicates likely influence of student degree CGPA to their engineering design competency. This suggests that student learning and training during their undergraduate program plays important role in acquiring this PO3 attribute. Therefore, although many factors may affect university performance (for example, background knowledge, attitude and study habits (Wahid et al., 2014), students are advised to focus on their undergraduate studies and adapt to learning culture in university.

Figure 3. Relationship between PO3 achievement and CGPA



Conclusion

A study to analyse relationship between matriculation and university performance, in terms of CGPA and design competency, of mechanical engineering degree students has been presented. CGPA results from matriculation for entry into university, CGPA results during degree program and program outcome PO3 results, for a batch of mechanical engineering students were compiled and analysed. Graphical and linear regression analyses indicate that performance in matriculation studies may not necessarily translate to academic performance during degree program. Although first year university performance was highest compared to

later years, significant drop in CGPA compared to matriculation CGPA suggest that perhaps students need to adapt to learning culture in university. In addition, improvement in CGPA during their fourth year of study may indicate that student may benefit from closer attention afforded during elective courses and thesis works.

Furthermore, competency of graduating students in engineering design solutions is not influenced by their matriculation performance, indicating importance of related teaching and learning experience during their degree program. The study presented here had been limited to a single cohort or batch of 30 mechanical engineering students in one institution. Another limitation in the current work is that data was based on a program curriculum before 2016, after which the mechanical engineering course hasundertaken major improvements in its syllabus and program. Therefore, results could be more generalized by taking data from more institutions and across several programs/curriculum.

Acknowledgement (Acknowledgement)

Authors would like to thank undergraduate officers from the Faculty of Engineering and Built Environment for their valuable assistance in compiling and sharing data of mechanical engineering students in this study. We would also like to thank Universiti Kebangsaan Malaysia (UKM) and Centre for Engineering Education Research (UKM) for financial support under grant STEM-2014-012 and AP-2015-015 respectively.

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