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Exploring Students' Achievements in Differential Equations Courses and Their Feelings Towards Mathematics Courses

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ABSTRACT

Differential equations are a fundamental area of mathematics that is widely used in various fields, including physics, engineering, economics, and more. However, many students find this course to be particularly challenging and struggle to achieve success in differential equations courses. Therefore, this study aims to investigate the relationship between students' achievements in midterm and final exams differential equations courses and their feelings towards mathematics courses, to provide a more comprehensive understanding of the factors that contribute to success in this challenging course. The results of this study indicate a positive correlation between students' achievements in differential equations courses and their feelings toward mathematics. Male students performed slightly better than female students for marks above 50. Additionally, students who enjoyed all the mathematics courses had higher grades in differential equations courses, which was statistically significant. These findings also highlight the importance of midterm exams as preparation before seating for the final exam of differential equations.

Keywords: Differential equation; Mathematics courses; Pearson correlation; Spearman correlation

INTRODUCTION

Mathematics is the main course that supports a large number of engineering courses in higher education institutions and it is important for students to have a solid knowledge of mathematics as a basis for studying engineering courses. Many studies have been conducted on student achievement in Engineering Mathematics (Alves et al. 2012a; Alves et al. 2012b; Asirifi et al. 2015; Hamzah et al. 2015; Ismail et al. 2011; Naccache and Hleiss, 2016; Zogheib et al. 2015). Student achievement is influenced by many factors such as the student's educational background and the student's final cumulative grade point average (CGPA) (Zogheib et al. 2015), the level of study, and the instructor's experience (Alves et al. 2012a; Alves, et al. 2012b; Ayebale et al. 2020; Naccache & Hleiss, 2016; Zogheib et al. 2015). In addition, student achievement is also said to be closely related to the construction or drafting of exam questions (Nopiah et al., 2012). Ayebale et al. (2020) found that teaching methods, teachers' attitudes, and students' attitudes toward mathematics were the factors affecting students' achievement at secondary schools in the area of developing countries in almost all articles reviewed.

Achievement in mathematics is also impacted by gender differences (Ayebale et al. 2020). According to studies, boys perform better in mathematics than females. This assumption tends to influence how girls feel about mathematics (Farooq and Shah, 2008).

Girls lacked confidence, had crippling causal attributional patterns, the thought of mathematics as a male realm, and expressed anxiety when compared to males in comparative studies (Kaerney and Garfield, 2019). In comparison to boys, girls were found to have lower maths self-confidence (Agyman and Ankum, 2015).

Moreover, many other factors need to be studied in addition to those mentioned above, such as student interests in mathematics. It can be measured based on the results of students' achievement in mathematics courses. For example, a study conducted by Leng (2006) found that interest has a high and positive influence on student achievement in mathematics subjects. The results of this study are also supported by Nordin (1994), in which a person who has a high interest in what is learned will usually show seriousness and high achievement.

All students in the Faculty of Engineering and the Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM), must enroll in three mathematics courses as part of the faculty requirements for the duration of their study. There are two courses offered for Year 1, which are Semester I Vector Calculus (Engineering Mathematics I, VC) and Semester II Linear Algebra (Engineering Mathematics II, LA). In addition, students are required to take the Differential Equations (Engineering Mathematics III, DE) course in Year 2 Semester I.

The DE course is a course that applies a lot of mathematics in the field of engineering. Therefore, every student should have a deep understanding of some important topics in VC and LA courses such as Differentiation, Integration, Series, and Matrices before taking the DE course. However, many students find DE to be particularly challenging and struggle to achieve success in differential equations courses. Therefore, this study aims to investigate the relationship between students' achievements in midterm and final exams differential equations courses and their feelings towards mathematics courses, to provide a more comprehensive understanding of the factors that contribute to success in this challenging course.

METHODOLOGY

RESEARCH DESIGN

This study adopted quantitative data collection methods. The quantitative component involved collecting numerical data on students' achievements through a midterm and final exam scores in differential equations (DE) courses, students' perceptions towards DE courses, and their feelings toward other mathematics courses.

PARTICIPANTS

The sample for this study consisted of 72 second-year undergraduate students in Semester 2 2022/2023 who were enrolled in DE courses at the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. The sample was selected using convenience sampling, with the participants being recruited through email invitations and classroom announcements.

DATA COLLECTION

Data for this study were collected using two instruments: a mathematics perception survey and a DE exam score. The mathematics perception survey consisted of demographic profiles of the students (age, number of siblings, students' entry qualification, and their department) and 20 Likert-type items that assessed students' perceptions of DE courses and feelings towards mathematics courses.

However, this study only focuses on their feelings about their enjoyment of studying mathematics courses related to DE exam scores. Mathematics courses were divided into two levels, which are at secondary school such as Mathematics (Math) and Additional Mathematics (AddMath), and university level such as Vector Calculus (VC), Linear Algebra (LA), and Differential Equations (DE). An example of the Likert scale used for their feelings is 1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree. The survey was given to the students after the midterm exam of the DE. The DE exam scores consist of the midterm exam and the final exam, which covered topics such as first-order differential equations, second-order differential equations, and Laplace transforms. The midterm exam was given in the middle of the semester while the final exam at the end of the semester.

DATA ANALYSIS

The quantitative data collected from the mathematics perception survey and the DE exam score were analyzed using descriptive statistics and correlation analysis.

LIMITATIONS

Convenience sampling was used in this study, which could have limited how broadly the results could be applied. The study was carried out at a particular institution, thus it might not indicate students' accomplishments and attitudes towards mathematics in other circumstances. The study also used self-reported data, which is vulnerable to response bias.

FORMULA USED

1. A descriptive formula

The mean, standard deviation, minimum and maximum values were calculated for all the variables used in this study such as exam scores and feelings towards mathematics courses. The formula for mean and standard deviation are given in equations (1) and (2).

$$mean = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

$$standard\ deviation = \frac{\sum_{i=1}^{n} (x_i - \underline{x}_i)^2}{n-1} \quad (2)$$

where i is the number of students, n =1,2,…72, and x_i exam scores for ith students.

2. Correlation

The existence and strength of a linear relationship between two variables are assessed using the Pearson correlation and Spearman correlation test.

The Pearson correlation test is for data in continuous form and the Spearman test is for ordinal data like Likert-type data. These two variables may have one of three sorts of linear relationships: a positive linear correlation, a negative linear correlation, or no association at all. Using these two hypotheses, this may be verified:

H0: There is no linear relationship between the two exams

H1: There is a linear relationship between the two exams

Pearson correlation test

$$r = \frac{\sum (x_i - \underline{x})(y_i - \underline{y})}{\sqrt{\sum (x_i - \underline{x})^2 \sum (y_i - \underline{y})^2}} \quad (3)$$

where r = Pearson correlation coefficient

x_i= values of the x-variable in the sample

$\underline{x}$ =mean of the values of the x-variable

y_i= values of the y-variable in the sample

$\underline{y}$ = mean of the values of the y-variable

Spearman correlation test

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (4)$$

where ρ = Spearman's rank correlation coefficient

d_i= difference between the two ranks of each observation

n= number of observations.

RESULTS AND DISCUSSION

DESCRIPTIVE STATISTICS

Descriptive statistics were calculated for the demographic students, perception towards other mathematics courses and differential equations exams. The mean, standard

TABLE 1. Descriptive statistics for demographic profiles and students' feelings toward mathematics courses

	Minimum	Maximum	Mean	Std. Deviation
Demographic profile				
1) Number of Siblings:	0	9	4.18	1.68
2) Age	20	25	21.51	1.01
Students feelings towards Mathematics courses				
3) I enjoy studying Mathematics [Math] at secondary school	2	5	4.33	.86
4) I enjoy studying Mathematics [AddMath] at secondary school	1	5	3.44	.93
5) I enjoy studying Vector Calculus [VC] at the university	1	5	3.28	1.02
6) I enjoy studying Vector Calculus [LA] at the university	2	5	3.75	.96
7) I enjoy studying Differential Equations [DE] at the university	2	5	3.50	.98
Midterm exam DE	15.00	97.50	51.82	19.28
Final exam DE	15.83	99.17	60.14	21.16

deviation, minimum, and maximum values for each variable were computed and are presented in Table 1. On average, the students have about four siblings, and their ages are around 21 years old.

Overall, the mean score of their feeling when studying mathematics shows that Mathematics (4.33) is the most enjoyable course, followed by Linear Algebra (3.75), Differential Equations (3.5), Additional Mathematics (3.44), and Vector Calculus (3.28). The minimum score is one in the table shows that students strongly agree with the statement that they do not enjoy learning AddMath and VC courses. For easy interpretation of the mean score of their feelings towards mathematics courses, the histogram was plotted in Figure 1.

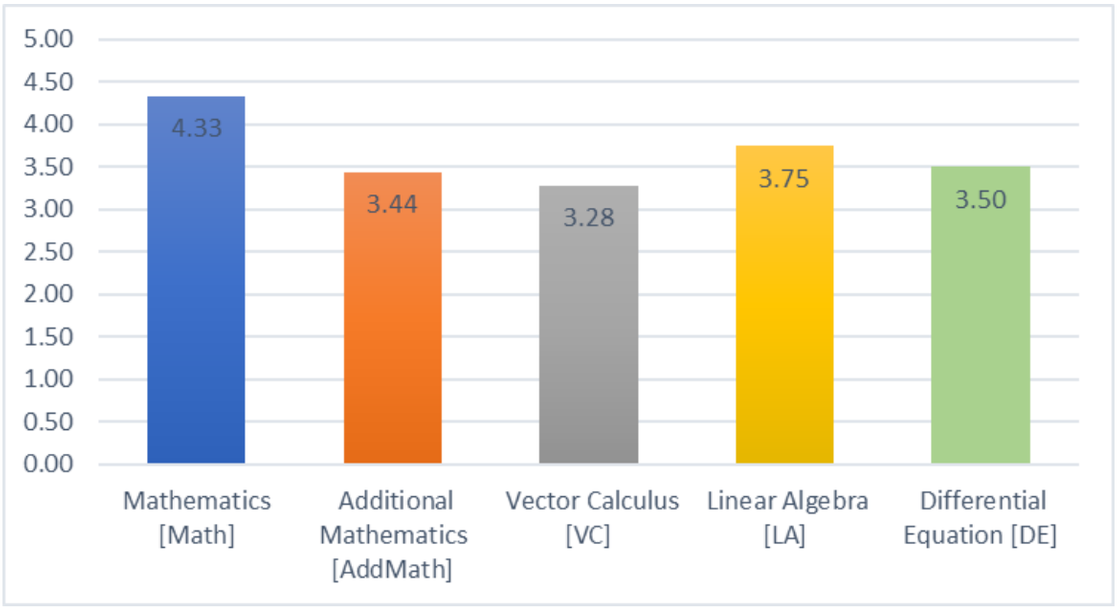

FIGURE 1. The overall mean score of students' feelings in each mathematics course

Figure 2 shows the students' entry qualification to FKAB, UKM as the participant in this study. The highest percentage of the students are from Matriculation (62%), followed by Foundation (21%), Diploma (14%), and STPM (3%).

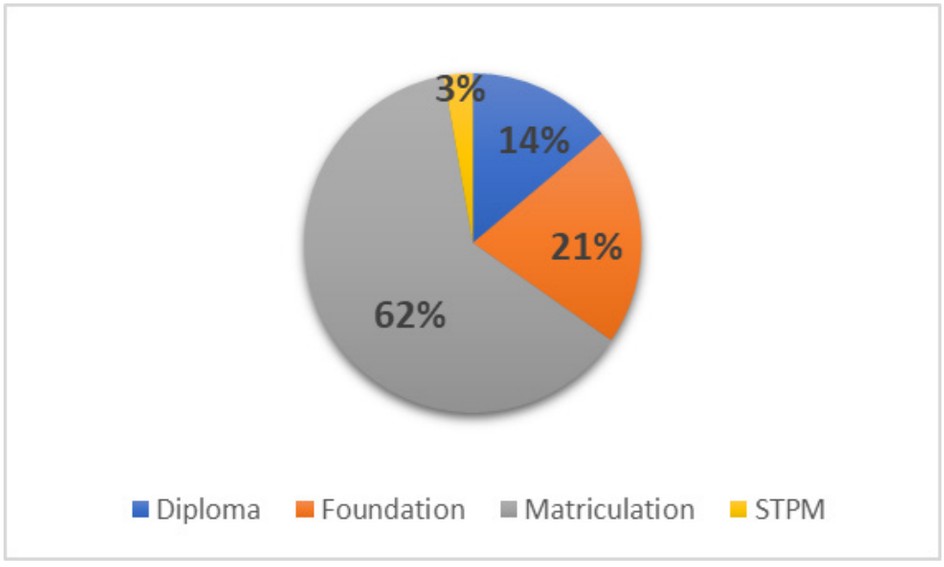

FIGURE 2. Percentage of Students' Entry Qualification

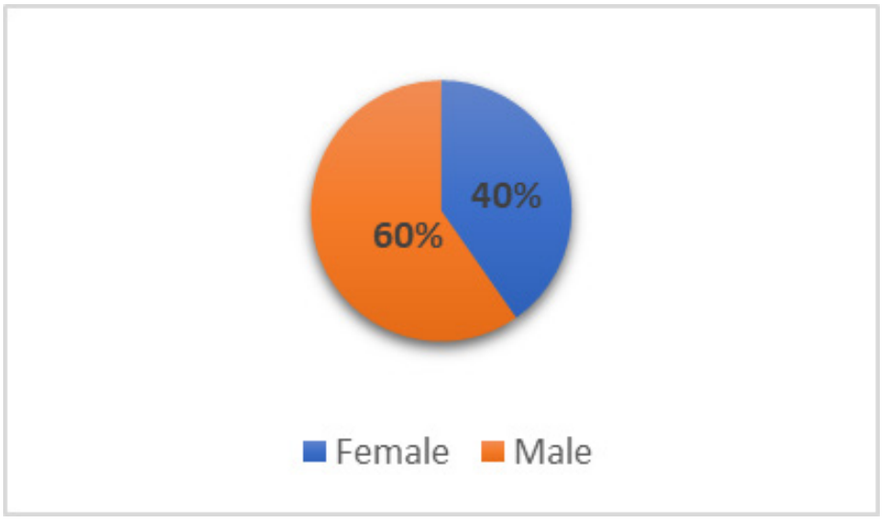

FIGURE 3. Percentage of students by gender

Figure 3 shows the percentage of students who participated in this study. Male shows a higher percentage with 60% (43 students out of 72) compared to female just about 40% (29 students out of 72).

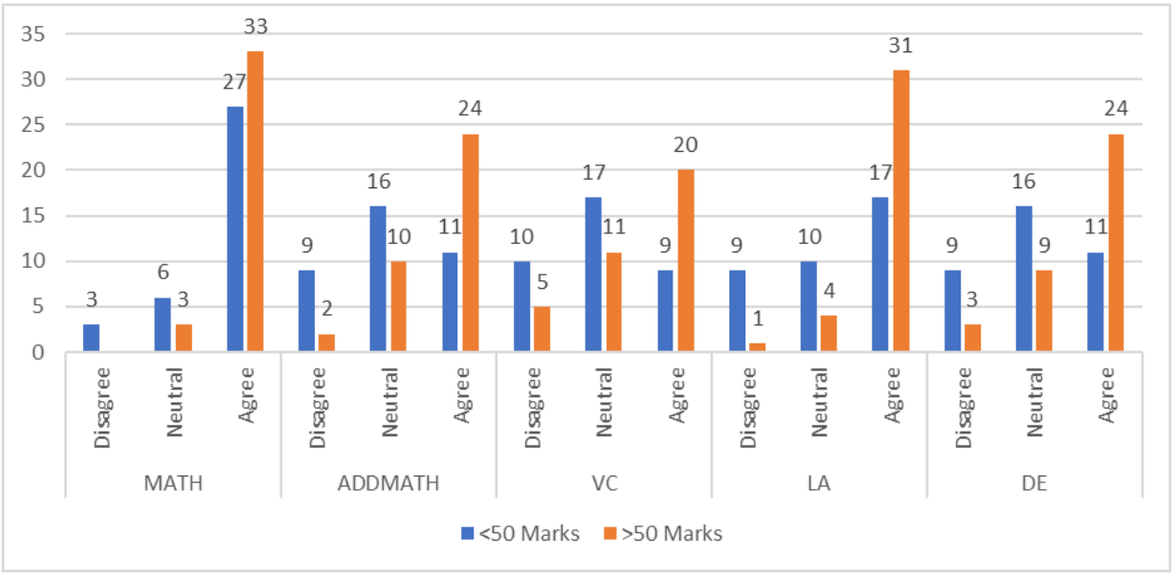

FIGURE 4. A comparison of the number of students feels enjoy studying mathematics between two groups of students' marks.

The mean and standard deviation for midterm and final exams of the DE in Table 1 shows there is no big difference between the two values which are 51.82 with a standard deviation of 19.28 and 60.14 with a standard deviation of 21.16, respectively. These exams were then divided into two groups: students who obtained less than 50 marks and students who had scores greater than 50 marks. The comparisons between these groups and their feeling toward mathematics courses were tabulated in Figure 4. Students who obtain greater than 50 marks in DE feel more enjoyable in studying mathematics courses compared to students who have less than 50 marks. The number of students with less than 50 marks who neither agree nor disagree with the feeling statements is higher compared to students who have greater than 50 marks.

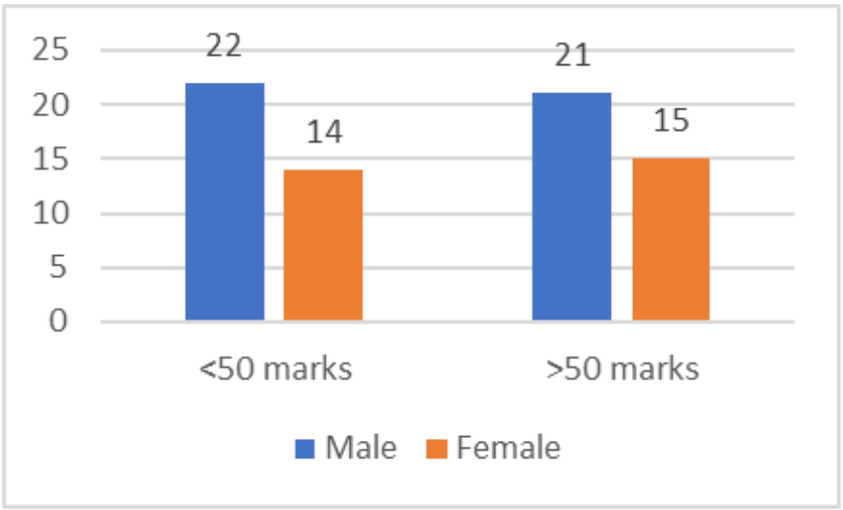

FIGURE 5. A comparison of gender between two groups of students' midterm marks

Figure 5 shows both groups of male students obtained greater than 50 marks (21 students) and less than 50 marks (22 students) in the midterm exams which is higher compared to female students with 15 and 14 students respectively.

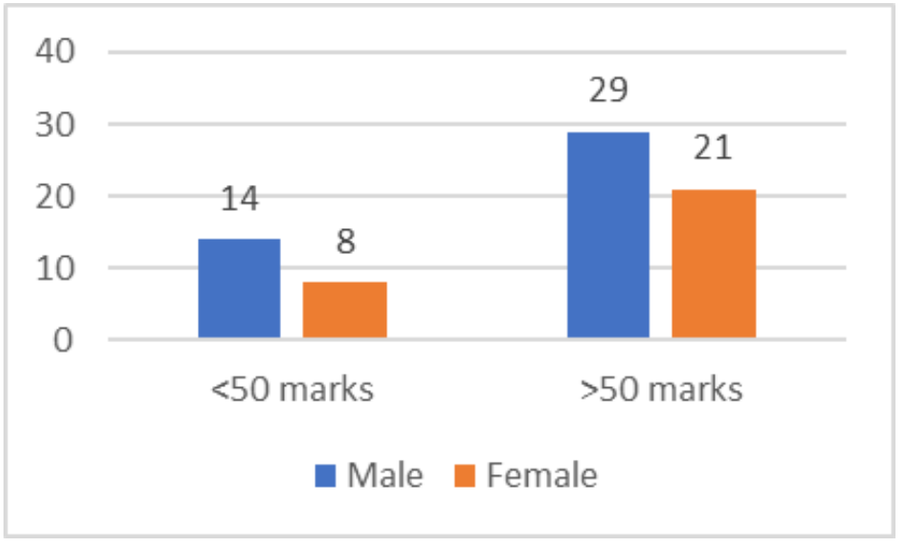

FIGURE 6. A comparison of gender between two groups of students' final marks

Furthermore, Figure 6 shows male students also obtained a higher number of students in both groups with 29 students (>50 marks) and 14 students (<50 marks) compared to female students who are 21 and 8 students respectively.

TABLE 2. Spearman Correlation Test between Mathematics Courses

Course		Spearman, (r) (r)	p-value	Course		Spearman, (r) (r)	p-value
MATH	AddMath	0.48*	0.00	VC	LA	0.66*	0.00
	VC	0.46*	0.00		DE	0.69*	0.00
	LA	0.50*	0.00	LA	DE	0.73*	0.00
	DE	0.55*	0.00				
ADDMATH	VC	0.51*	0.00				
	LA	0.50*	0.00				
	DE	0.55*	0.00				

*Correlation significant at 0.05 level

CORRELATION ANALYSIS

A Spearman correlation analysis was conducted to investigate the students' feelings about mathematics courses while Pearson tested the relationships between midterm and final exams of DE and the average score of students' feelings for all mathematics courses (AllMath).

The Spearman correlation test in Table 2 shows all of the mathematics courses significantly correlated with each other($r>0.50$,$p - value < 0.05$). This result reveals that students who enjoy one of the mathematics courses will enjoy the other mathematics course.

The results of the Pearson correlation in Table 3 showed that students' achievements in DE (both final and midterm exam) courses were positively correlated with the average score for all mathematics courses ($0.28< p < value < 0.05$). These results also suggest that students who have a positive feeling towards mathematics tend to perform better in DE courses.

TABLE 3. Pearson correlation between DE exams scores and the average score of student's feelings for all Mathematics course

	Pearson, (ρ) (ρ)	p-value
Midterm-Final	0.58*	0.00
Midterm-AllMath	0.44*	0.00
Final-AllMath	0.28*	0.02

*Correlation significant at 0.05 level

CONCLUSION

The results of this study indicate a positive correlation between students' achievements in differential equations courses and their feelings toward mathematics. Male students performed slightly better than female students for marks above 50. Additionally, students who enjoyed all the mathematics courses had higher grades in differential equations courses, which was statistically significant. Therefore, to attract students' interest and feelings to enjoy the mathematics course at the early stages, teachers at primary and secondary schools play an important role in making this course more enjoyable.

These findings also highlight the importance of midterm exams as preparation before seating for the final exam of DE. The lecturer could focus on the students who have less than 50 marks in midterms exams by giving extra exercises to them. This may help to improve students' achievements in the DE course.

It is recommended that future research explore the specific factors that influence students' perception of mathematics and how they affect their performance in DE courses. This could help to identify specific interventions that can be implemented to further improve students' achievements in these courses.

In summary, this study has provided important insights into the factors that influence students' achievements in DE courses. The findings have implications for instructors, curriculum developers, and policymakers who are interested in promoting better performance and success among students in mathematics-related fields.

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REFERENCES

Agyman OK, Nkum D. 2015. Factors Influencing Students' Mathematics Performance in Some Selected Colleges of Education in Ghana. *International Journal of Education Learning and Development* 3(3): 68–74.

Alves, M., Rodrigues C. S. & Rocha, A. M. A. C. 2012a. Engineering students and mathematics achievement: A Portugese case study. *Proceedings of the World Congress on Engineering* 1: 89-94.

Alves, M., Rodrigues C. S. & Rocha, A. M. A. C. 2012b. Mathematics Achievement In Engineering: An Exploratory Study With MIEGI Students. *International Conference on Industrial Engineering and Operations Management (ICIEOM):* 1-8.

Asirifi, M. K., Mensah, K. A. & Amoako, J. 2015. An assessment of different educational background of students performance in Engineering Mathematics and on the class of award obtained at the Higher National Diploma (HND) level at Cape Coast Polytechnic, Ghana. *Journal of Education and Practice* 6(9): 117-125.

Ayebale, L., Habaasa, G. & Tweheyo, S. 2020. Factors affecting students' achievement in mathematics in secondary schools in developing countries: A rapid systematic review. Statistical Journal of the IAOS. 36. 1-4. 10.3233/SJI-200713.

Farooq, M. & Shah, S. (2008). Students' attitude towards mathematics. *Pakistan Economic and Social Review* 46(1): 75–83.

Hamzah, F.M., Kamarulzaman, P. S. D., Ismail, N. A.; & Jafar, K. 2015. Students' performance in Engineering Mathematics courses: Vector calculus versus differential equations. *Journal of Engineering Science and Technology.* Special Issue on UKM Teaching and Learning Congress 2013, 91-97.

Ismail, N. A., Nopiah, Z. M., Asshaari, I., Othman, H., Tawil, N. M. & Zaharim, A. 2011. Mathematical Performance of Engineering Students in Universiti Kebangsaan Malaysia (UKM). *Procedia - Social and Behavioral Sciences* 60: 206-211.

Kearney, W.S & Garfield, T. 2019. Student readiness to learn and teacher effectiveness: Two key factors in middle grades mathematics achievement. *RMLE Online* [Internet]. 2019; 42(5): 1–12. Doi: 10.1080/19404476.2019.1607138.

Leng, Q. M. 2006. Pengaruh Rakan Sebaya dengan Pencapaian Matematik di Kalangan Pelajar Tingkatan 4 di Daerah Batu Pahat. Tesis Sarjana Muda. Universiti Teknologi Malaysia.

Naccache, H. & Hleiss, R. 2016. Multivariate analysis of students's performance in math course and specific engineering courses. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering* 10(3): 918-923.

Nopiah, Z. M., Jamalluddin, M. H., Ismail, N. A., Othman, H., Asshaari, I. & Osman, M, H. 2012. Reliability of examination questions in a Mathematics course using Rasch Measurement Model. Malaysiana 41(9): 1171-1175.

Nordin, A. B. 1994. *Reformasi Pendidikan dalam Menghadapi Cabaran 2020*. Kuala Lumpur: Cetaktama Press.

Zogheib, S., Zogheib, B. & Saheli, A. E. 2015. University student's achievement in mathematics: The role of students' gender, instructor's gender, educational level and experience. *The Mathematics Educator* 16(1): 75-90.