Research in Engineering Education Symposium (REES)
Regional Conference in Engineering Education (RCEE) &
Research in Higher Education (RHEd)
September 29 – October 3, 2025
Johor, Malaysia

Exploring the Relationship Between Attendance, Gender, and Academic Performance in a Differential Equations Course

Nur Arzilah Ismail[a,b], Nuryazmin Ahmat Zainuri[a,b], Noorhelyna Razali[a,b], Muhammad Imran Najeeb[a,b], Mohd Hanif Osman[a,b], Izamarlina Asshaari[a,b], Mohd Alias Md Jedi[c]

[a]Department of Engineering Education, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor.
[b]Centre of Engineering Education, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor.
[c]Department of Mechanical and Process Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor.
Corresponding Author's Email: azila@ukm.edu.my

ABSTRACT

BACKGROUND & CONTEXT

Differential Equations (DE) is a challenging engineering course that requires strong conceptual understanding and consistent engagement in structured learning activities. Although attendance is known to influence academic success, gender-related differences in learning behaviours in mathematics-intensive subjects are still not well understood.

PURPOSE OR GOAL

This study examines how structured attendance and gender relate to exam performance in Differential Equations, focusing on whether attendance predicts scores and whether males and females differ in their engagement and outcomes.

APPROACH OR METHODOLOGY

This study analysed data from 77 civil engineering undergraduates at UKM by examining their structured attendance (lectures, tutorials, maths clinics) and exam scores using descriptive statistics, correlation, and t-tests.

OUTCOMES

Lecture and tutorial attendance showed moderate, significant correlations with exam performance, while maths clinic attendance was very low and had no impact. Female students attended more consistently than males, but their performance was not significantly different.

CONCLUSIONS

Structured attendance, especially in lectures, is key to success in DE, while gender differences in engagement do not affect performance, and low maths clinic participation suggests the need for redesign and further multi-cohort research.

KEYWORDS

Attendance, Gender, Differential Equations, Self-Regulated Learning.

Introduction

Differential Equations (DE) is a core course in engineering programs that requires strong mathematical and conceptual skills. These skills are essential for other engineering courses, such as fluid dynamics, signal processing, and mechanical systems analysis. Despite its importance, many students struggle to perform well; however, consistent classroom engagement and structured learning environments can enhance their understanding of the course material.

Attendance has consistently been recognized as a key predictor of student performance in engineering mathematics courses. Recent research by Yeo et al. (2025) examined student outcomes before and after the COVID-19 pandemic and found that higher lecture attendance significantly contributed to academic achievement.

In parallel, researchers have increasingly focused on how gender influences learning in STEM education. Chen et al. (2025) found that gender role stereotypes negatively influenced high school girls' STEM performance, with educational aspirations acting as a full mediator of this relationship. In other words, stereotypes primarily affected performance by lowering students' aspirations. Although the study was conducted at the pre-university level, it suggests that similar psychological mechanisms may also shape performance in university contexts.

Students' performance in mathematics is influenced by multiple factors, including teaching methods, teachers' attitudes, students' attitudes, classroom environment, parental support, prior mathematics achievement, and gender-related factors (Ayebale et al., 2020). Additionally, students' enjoyment of mathematics has been shown to positively correlate with performance in Differential Equations; those who enjoyed multiple math subjects achieved higher exam scores (Ismail et al., 2023).

Large-scale studies indicate that global gender differences in mathematics achievement have significantly narrowed, with male and female students now performing at nearly equivalent levels (Charlesworth & Banaji, 2019). Within engineering education, however, research continues to show that female students often demonstrate stronger academic engagement than their male peers, even in contexts where performance differences are minimal or inconsistent (Bowman et al., 2022).

Past research on engineering mathematics at UKM provides additional context for this study. Ismail et al. (2012) demonstrated that weak mathematical foundations significantly hinder engineering students' performance, underscoring the need for consistent engagement in core courses such as DE. Similarly, Othman et al. (2015) and Asshaari et al. (2012) highlighted how objective assessment tools, such as the Rasch Measurement Model, can be used to evaluate exam quality and diagnose weaknesses in student learning. Pedagogical innovations have also been examined: Tawil et al. (2013) reported that e-learning improved students' understanding when adapted to their learning styles, while Othman et al. (2012) and Asshaari et al. (2011) found that cooperative learning enhanced students' motivation and confidence in engineering mathematics courses. Collectively, these studies highlight the importance of structured engagement, data-informed assessment, and student-centred teaching methods in shaping outcomes in engineering mathematics.

Despite these insights, limited research has examined the combined influence of attendance, gender, and academic achievement within the context of mathematically intensive engineering subjects such as Differential Equations. The present study addresses this gap by concurrently analysing these variables. Framing attendance through self-regulated learning theory (Zimmerman, 2002) and experiential learning theory (Kolb, 1984) provides a deeper pedagogical lens for understanding how engagement influences outcomes.

At the Faculty of Engineering and the Built Environment (FKAB), Universiti Kebangsaan Malaysia (UKM), all engineering students are mandated to enrol in three mathematics courses as part of the faculty's curriculum throughout their academic tenure. In Year 1, students

https://doi.org/10.52202/086293-0097

undertake two courses: Vector Calculus (Engineering Mathematics I, VC) in Semester I and Linear Algebra (Engineering Mathematics II, LA) in Semester II. Subsequently, in Year 2, Semester I, students are required to complete the Differential Equations course (Engineering Mathematics III, DE). These engineering mathematics courses are delivered by lecturers from the Department of Engineering Education (JPK). The DE course emphasizes the extensive application of mathematical principles within engineering contexts. However, many students find this course particularly challenging and encounter difficulties in achieving satisfactory performance.

This study aims to explore the relationship between gender, attendance, and student performance on the midterm and final examinations of the DE course. The findings are intended to provide a comprehensive understanding of the factors contributing to success in this demanding course.

Methodology

Research Design

This study employed a quantitative research design to examine the relationship between structured attendance, gender, and academic performance in a Differential Equations (DE) course. The design focused on numerical data collection and statistical analysis to identify patterns and relationships among the variables. Attendance was considered not only as a record of presence but also as a behavioural indicator of student engagement, consistent with self-regulated learning theory (Zimmerman, 2002), which emphasizes discipline and consistency, and experiential learning theory (Kolb, 1984), which underscores the importance of practice-based activities such as tutorials and clinics.

Participants

The sample comprised 77 second-year undergraduate civil engineering students enrolled in the DE course during Semester 2 of the 2023/2024 academic year at the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia. This course is compulsory for all second-year engineering students, ensuring a consistent cohort of participants. While the sample size offers valuable insights, it is limited to a single programme, institution, and semester, which restricts the generalisability of the findings.

Data Collection and Analysis

Daily lecture attendance was recorded using the Smart Attendance UKM system, while attendance for tutorials and the Maths Clinic was tracked through an online QR code system. Academic performance was assessed based on midterm and final examination scores.

Lectures were delivered by the course lecturer and consistently conducted from Week 1 to Week 14, with each lecture lasting three hours. In contrast, tutorials and the Maths Clinic were conducted by tutors and only began in Week 4. Tutorials were compulsory, held once a week for one hour, and typically involved discussing assignments or problem sets provided by the lecturer.

The Maths Clinic was voluntary and designed as a support initiative by JPK to assist students who were weaker in mathematics. Its introduction was motivated by the consistently high failure rates in the DE course observed over the years, which underscored the need for additional academic support. Each Maths Clinic session lasted two hours and was offered twice a week, allowing students to attend flexibly when they were not scheduled for laboratory classes or other courses. The clinic was student-driven: participants were encouraged to ask questions about topics they did not understand. When students did not raise questions, the tutor facilitated discussions by working through additional problems related to that week's lecture content.

Formula Used

The analysis employed descriptive statistics, Pearson's correlation, and independent-samples t-tests.

A Descriptive Formula

The mean, standard deviation, minimum, and maximum values were calculated for all the quantitative variables used in this study, such as attendance and exam scores. The formulas for the mean and standard deviation are provided in the equation (1) and (2).

$$\text{Mean} = \frac{\sum_{i=1}^{n} x_i}{n} \quad \ldots(1)$$

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x}_i)^2}{n-1}} \quad \ldots(2)$$

where *i* is the number of students, n =1,2,…77 and x_i attendance/exam scores for *i*th students.

Pearson Correlation

The existence and strength of a linear relationship between two variables continuous data are assessed using the Pearson correlation. 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:

H_0: There is no linear relationship exists between attendance and performance.

H_1: There is a significant linear relationship exists between attendance and performance.

Pearson correlation test

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}\left((x_i - \bar{x})\right)^2 \sum_{i=1}^{n}\left((y_i - \bar{y})\right)^2}} \quad \ldots(3)$$

where r = Pearson correlation coefficient

x_i= values of the x-variable in the sample

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

y_i= values of the y-variable in the sample

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

Independent t-test

To examine the differences in structured attendance and academic performance between male and female students, an independent samples t-test was conducted. This statistical test is appropriate for comparing the means of two independent groups (male and female students) on continuous variables such as lecture attendance, tutorial attendance, maths clinic attendance, and midterm and final exam scores. The hypothesis for the t-test is as follows:

H0: There is no significant difference between male and female students regarding structured attendance (lectures, tutorials, and math clinics) and academic performance (midterm and final examination scores) in the DE course.

H1: There is a significant difference between male and female students regarding structured attendance and academic performance in the DE course.

https://doi.org/10.52202/086293-0097

Limitations of the Study

This study has several limitations that should be acknowledged. First, the analysis was based on a single cohort from one institution and covered only one semester, which restricts the generalizability of the findings to broader student populations or different academic contexts. Second, the study relied exclusively on quantitative measures of attendance and performance, without capturing the motivational, perceptual, or contextual factors that may influence students' attendance decisions. As a result, important insights into why students chose to attend or skip tutorials and Maths Clinics could not be explored. Future research should therefore adopt multi-institutional and longitudinal designs, and complement statistical analysis with qualitative approaches such as surveys, interviews, or focus groups to provide a more holistic understanding of student engagement in engineering mathematics courses.

Results and Discussion

Table 1 presents the descriptive statistics for students' structured attendance and examination performance in the DE course. Lecture attendance was relatively high (M = 82.26, SD = 17.09), reflecting consistent engagement with the main instructional sessions. This is expected, as lectures were compulsory and constituted the primary mode of content delivery. Similar trends have been reported in other engineering mathematics courses, where lecture attendance was identified as a strong predictor of student performance (Yeo et al., 2025).

Tutorial attendance was considerably lower (M = 47.92, SD = 30.91, Min = 0), with a wide spread indicating substantial variation. This suggests that while some students engaged actively, others did not attend at all. Such patterns are consistent with self-regulated learning theory (Zimmerman, 2002), which explains how students allocate effort based on confidence and perceived utility.

Attendance at the maths clinic was the lowest (M = 11.95, SD = 20.07), again with high variability: a small group of students attended regularly, but many never attended. Its voluntary and remedial positioning may have contributed to this underuse, potentially carrying a stigma. From an experiential learning perspective (Kolb, 1984), this reflects missed opportunities for practice-based support, particularly for weaker students.

In terms of performance, the mean midterm score was 56.60 (SD = 16.70), while the mean final exam score increased to 67.38 (SD = 15.87), suggesting overall improvement. Both assessments showed wide ranges (Midterm: 26.67–91.67; Final: 21.43–94.29), indicating considerable variation in achievement. This variation is consistent with earlier findings that students' attitudes and enjoyment of mathematics play an important role in shaping outcomes in DE (Ismail et al., 2023).

Table 1: Descriptive statistics for structured attendance (%) and exam scores (%) in the DE course

Variable	Mean	Standard Deviation	Min	Max
Attendance				
Lecture	82.26	17.09	37	100
Tutorial	47.92	30.91	0	100
Maths Clinic	11.95	20.07	0	100
Exam scores				
Midterm	56.6	16.7	26.67	91.67
Final exam	67.38	15.87	21.43	94.29

Figure 1 shows the gender distribution of the 77 students enrolled in the DE course. Female students comprised 62.3% of the cohort, compared to 37.7% male. This imbalance provides important context for interpreting subsequent results, as the higher proportion of female students aligns with the descriptive finding of greater female attendance across lectures, tutorials, and the Maths Clinic. However, this distribution should not be interpreted as reflecting ability differences, since global evidence indicates that gender gaps in mathematics performance are now minimal (Charlesworth & Banaji, 2019).

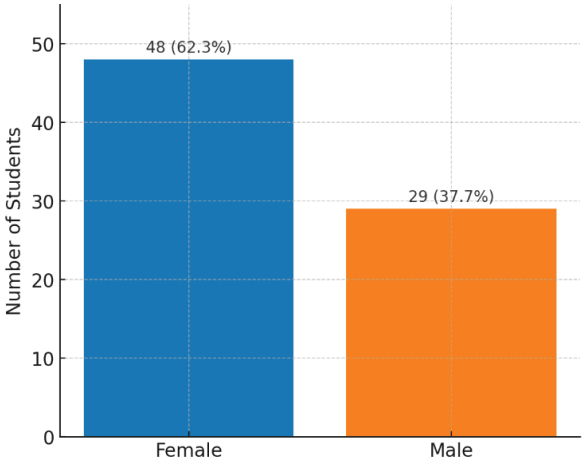


Figure 1: Gender Distribution of Students in DE Course

Figure 2 presents average attendance rates across the three structured activities by gender. Female students consistently demonstrated higher attendance. In lectures, females attended nearly 90% of sessions, compared to approximately 71% among males. The disparity was more pronounced in tutorials, where female attendance exceeded 60%, while male attendance dropped to around 25%. Attendance at the Maths Clinic was the lowest for both genders, though female participation was slightly higher.

This consistent pattern highlights gender-based differences in engagement. Female students appeared to exercise stronger self-regulation and greater commitment to structured learning opportunities.

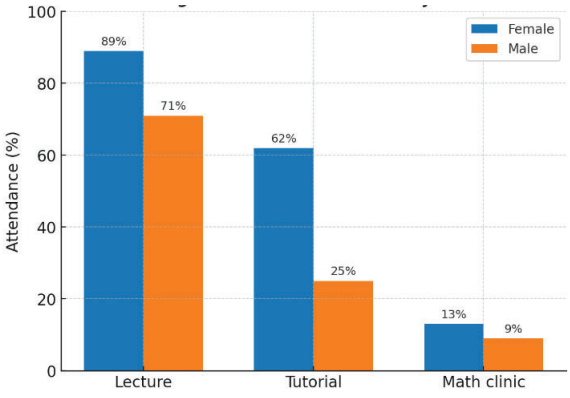


Figure 2: Average structured attendance by gender

Figure 3 illustrates the average examination performance of male and female students in the DE course, specifically on the midterm and final exams. Female students achieved slightly higher scores in both assessments, with a midterm mean of approximately 59 compared to 53 for males, and a final mean of around 68 compared to 66 for males. Although females demonstrated a consistent advantage, these differences were small and not statistically significant.

https://doi.org/10.52202/086293-0097

When considered alongside attendance data, these results suggest that higher lecture and tutorial attendance among female students may have supported their conceptual understanding and exam preparedness. However, the lack of significant performance differences indicates that, while gender influences attendance behaviours, it does not independently determine academic outcomes in mathematically intensive courses like DE.

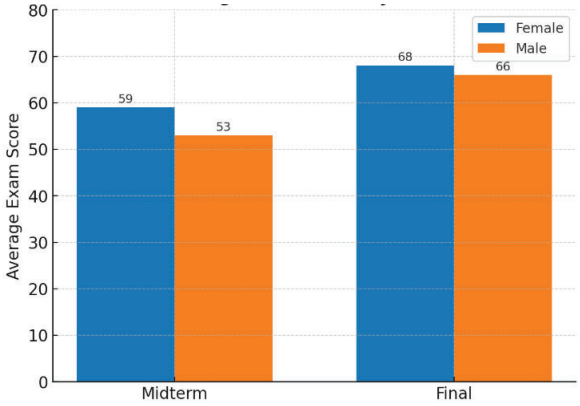


Figure 3: Average exam scores by gender

The results in Figure 4 show a moderate positive correlation between lecture attendance and final exam scores (r = 0.41) as well as midterm scores (r = 0.35). This indicates that consistent lecture participation tends to be associated with better exam outcomes. Tutorial attendance also exhibits a weak positive correlation with both midterm (r = 0.27) and final exam scores (r = 0.26), suggesting that tutorials contribute less to academic performance compared to lectures. In contrast, attendance at the maths clinic does not show a meaningful correlation with exam scores and even displays slight negative values (r = -0.09 for midterm, r = -0.14 for final), potentially indicating that students who frequently attend the clinic may be those already struggling.

The strongest correlation is observed between midterm and final scores (r = 0.60), indicating consistency in student performance across assessments. These findings reinforce the importance of lecture attendance in mastering course content and support prior research advocating structured class participation as a key contributor to success in technical subjects such as DE. These findings also highlight the significance of midterm examinations as preparation for sitting the final DE exam.

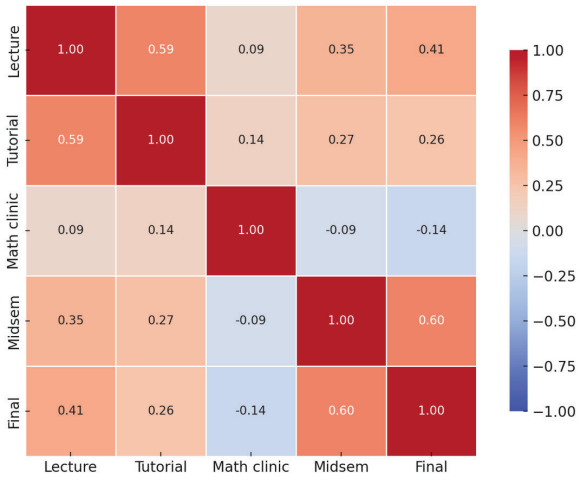


Figure 4: Correlation Matrix of Attendance and Exam Scores

Table 2: T-test results by gender

Variable	t-statistics	p-value	Significant?
Lecture	4.69	2.60E-05	Yes
Tutorial	7.06	7.26E-10	Yes
Maths clinic	1.14	0.25	No
Midterm	1.73	0.08	No
Final	0.61	0.54	No

Independent samples t-tests were conducted to examine gender-based differences in structured attendance and academic performance, as presented in Table 2. Significant differences were observed in both lecture attendance ($t(38) = 4.69$, p-value < 0.001) and tutorial attendance ($t(38) = 7.06$, p-value < 0.001), with female students attending more consistently than male students. These findings suggest that female students exhibited greater engagement and discipline in attending structured learning sessions, a behaviour consistent with patterns reported in the literature (Bowman et al., 2022) and indicative of self-regulated learning behaviours.

In contrast, no significant gender differences were observed in maths clinic attendance ($t(38) = 1.14$, p-value = 0.25), midterm scores ($t(38) = 1.73$, p-value = 0.088), or final scores ($t(38) = 0.61$, p-value = 0.54). These findings indicate that although female students attended structured sessions more regularly, this did not result in significantly higher performance outcomes.

Overall, the analysis indicates that gender influences engagement but not academic achievement within the DE course. This distinction is significant, as it highlights the need for interventions that encourage greater participation among male students without presuming inherent performance disadvantages. For instructors, this suggests that attendance policies and engagement strategies should be designed to motivate both genders equally, ensuring that attendance behaviours consistently support performance across the cohort.

Conclusion

This study explored the relationship between structured attendance, gender, and academic performance in a Differential Equations course among civil engineering undergraduates at FKAB, UKM. Building on prior research that has highlighted the role of teaching methods, attitudes, and mathematical foundations in shaping achievement (Ismail et al., 2012; Othman et al., 2015; Tawil et al., 2013; Asshaari et al., 2012), the findings confirm that consistent attendance, particularly in lectures, remains a key driver of academic success in mathematically intensive courses. Lecture attendance was moderately correlated with both midterm and final examination scores, while tutorials showed weaker but positive effects. In contrast, attendance at the maths clinic was minimal and showed no significant impact, reflecting its voluntary and remedial positioning.

Gender-based analyses revealed that female students attended lectures, tutorials, and the maths clinic more frequently than their male counterparts, consistent with broader evidence of stronger academic engagement among women in STEM (Bowman et al., 2022). However, these differences in attendance did not translate into significant performance gaps, supporting global evidence that gender differences in mathematics achievement have narrowed (Charlesworth & Banaji, 2019). This distinction contributes to the literature by demonstrating that in Differential Equations, structured attendance and engagement behaviours, rather than gender itself, shape outcomes.

The study also highlights the importance of midterm examinations as diagnostic tools for identifying at-risk students. Given the strong correlation between midterm and final scores, targeted interventions such as compulsory maths clinic participation, supplementary exercises,

https://doi.org/10.52202/086293-0097

or structured tutorials could help weaker students improve their final outcomes. At the curriculum level, tutorials and clinics should be repositioned to enhance their value, for example by embedding graded components, adopting cooperative or active learning approaches (Othman et al., 2012; Asshaari et al., 2011), and ensuring scheduling does not clash with other courses. These steps could reduce perceptions of tutorials and clinics as optional or remedial and promote more consistent participation.

Like many single-cohort studies, the scope of this research was limited to one institution and one semester, relying exclusively on quantitative data. These constraints restrict generalisability and overlook motivational or perceptual factors that influence attendance behaviours. Future research should therefore adopt multi-institutional and longitudinal designs and integrate qualitative approaches, such as surveys, interviews, or student reflections, to provide a more holistic understanding of how motivation and perceptions shape engagement.

By situating the findings within self-regulated learning theory (Zimmerman, 2002) and experiential learning theory (Kolb, 1984), this study underscores the complex interplay of behaviour, motivation, and structure in supporting student success. It further reinforces the importance of designing engineering mathematics curricula that not only assess performance but also cultivate sustained engagement through structured, student-centred, and data-informed teaching practices.

References

Asshaari, I., Othman, H., Bahaludin, H., Ismail, N. A., & Nopiah, Z. M. (2012). Appraisal on Bloom's separation in f inal examination question of engineering mathematics courses using Rasch measurement model. Procedia - Social and Behavioral Sciences, 60, 172–178.

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.

Bowman, N. A., Logel, C., LaCosse, J., Jarratt, L., Canning, E. A., Emerson, K. T. U., & Murphy, M. C. (2022). Gender representation and academic achievement among STEM-interested students in college STEM courses. *Journal of Research in Science Teaching, 59*(10), 1876–1900. https://doi.org/10.1002/tea.21778

Charlesworth, T. E. S., & Banaji, M. R. (2019). Gender in science, technology, engineering, and mathematics: Issues, causes, solutions. *Journal of Neuroscience, 39*(37), 7228–7243. https://doi.org/10.1523/JNEUROSCI.0475-18.2019

Chen, P., Hassan, A. B., Hamzah, F. M., Murad, S. S., & Wu, H. (2025). Impact of gender role stereotypes on STEM academic performance among high school girls: Mediating effects of educational aspirations. *STEM Education*, *5*(4), 617–642. https://doi.org/10.3934/steme.2025029

Ismail, N. A., Ahmat Zainuri, N., Razali, N., Nopiah, Z. M., Md. Jedi, M. A., Othman, H., & Wan Zin, W. Z. (2023). *Exploring students' achievements in differential equations courses and their feelings towards mathematics courses*. Jurnal Kejuruteraan, SI 6(2), 127–134. https://doi.org/10.17576/jkukm-2023-si6(2)-14

Ismail, N. A., Nopiah, Z. M., Asshaari, I., Othman, H., Tawil, N. M., & Zaharim, A. (2012). Mathematical performance of engineering students in Universiti Kebangsaan Malaysia (UKM). Procedia - Social and Behavioral Sciences, 60, 206–211.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. Prentice Hall.

Othman, H., Asshaari, I., Bahaludin, H., Tawil, N. M., & Ismail, N. A. (2012). Students' perceptions on benefits gained from cooperative learning experiences in engineering mathematics courses. Procedia - Social and Behavioral Sciences, 60, 500–506.

Othman, H., Ismail, N. A., Asshaari, I., Hamzah, F. M., & Nopiah, Z. M. (2015). Application of Rasch measurement model for reliability measurement instrument in vector calculus course. Journal of Engineering Science and Technology, 10(2), 77–83.

Tawil, N. M., Ismail, N. A., Asshaari, I., Othman, H., Zaharim, A., & Bahaludin, H. (2013). Preference learning style in engineering mathematics: Students' perception of e-learning. International Education Studies, 6(6), 61–65.

Yeo, W.S., Loo, V.H., Chiong, C.W.R. (2025). Relationship Between Class Attendance and Student Performance for an Engineering Mathematics Unit in the Pre-and Post-COVID Pandemic. In: Zainuddin, Z., Sumintono, B., Perera, C.J. (eds) Resilient and Sustainable Education Futures.

Sustainable Development Goals Series. Springer, Singapore. https://doi.org/10.1007/978-981-96-4971-6_18
Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

Acknowledgements

The author would like to acknowledge the support of Department of Engineering Education and Centre for Engineering Education Research (P3K), UKM for the financial support in this work.

Copyright Statement

Copyright © 2025 Authors' names (Nur Arzilah Ismail, Nuryazmin Ahmat Zainuri, Noorhelyna Razali, Muhammad Imran Najeeb, Mohd Hanif Osman, Izamarlina Asshaari, Mohd Alias Md Jedi): The authors assign to the Research in Engineering Education Netork (REEN) and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full, and this copyright statement is reproduced. The authors also grant a non-exclusive licence to REEN to publish this document in full on the World Wide Web (prime sites and mirrors), on portable media and in printed form within the REES and RCEE & RHEd 2025 proceedings. Any other usage is prohibited without the express permission of the authors.

https://doi.org/10.52202/086293-0097