International Journal of Modern Education
EISSN: 2637-0905
Volume 7 Issue 24 (March 2025) PP. 640-650
DOI: 10.35631/IJMOE.724045

INTERNATIONAL JOURNAL OF MODERN EDUCATION (IJMOE)
www.ijmoe.com

STUDENT PERFORMANCE IN BASIC STRUCTURAL ANALYSIS: OUTPUT FROM COURSE AND PROGRAM OUTCOMES

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Article Info:

Article history:
Received date: 31.07.2024
Revised date: 13.10.2024
Accepted date: 26.11.2025
Published date: 16.03.2025

To cite this document:

Imran, N. F., Hashim, N. H., & Hasan, D. (2025). Student Performance In Basic Structural Analysis: Output From Course And Program Outcomes. *International Journal of Modern Education, 7* (24), 640-650.

DOI: 10.35631/IJMOE.724045

Abstract:

In the ever-changing field of engineering education, the success of students relies heavily on the effectiveness of teaching methods and assessment strategies in fundamental courses like Basic Structural Analysis. This study analyses student performance over three semesters (20212, 20222, 20224) in the Basic Structural Analysis course, a fundamental part of the Diploma in Civil Engineering curriculum. By examining student results, it can seek to identify performance trends, assess the impact of teaching methods, and evaluate the correlation between student feedback and learning outcomes. The results show a notable decrease in test scores and the achievement of both Program Outcomes (PO) and Course Outcomes (CO), especially during semester 20224. The analysis identifies common issues like cognitive overload from excessive testing and insufficient student engagement in online classes. Based on these findings, the study recommends targeted interventions, including modifying assessment strategies and improving interactive teaching methods, to address the identified challenges and enhance overall student performance. This research highlights the importance of continuous feedback and adaptive teaching strategies in ensuring the effectiveness of foundational courses in civil engineering education, ultimately contributing to the development of skilled engineering professionals.

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Keywords:

Basic Structural Analysis, Civil Engineering Curriculum, Student Performance, Course Outcome, Program Outcome

Introduction

Civil engineering relies on fundamental courses that provide students with the essential knowledge and skills for their future careers. The Basic Structural Analysis course is one of the subjects ad act as a key component of the Diploma in Civil Engineering program at Universiti Teknologi MARA (UiTM). This course teaches students the principles of structural analysis, which are essential for comprehending structural behavior and ensuring the safety and stability of structures through analytical methods.

Due to its importance for the students, it is crucial to continually evaluate and improve the teaching and learning processes for this course. Recent educational trends highlight the need for effective teaching methods, thorough assessment strategies, and the integration of student feedback to enhance educational outcomes. According to Guskey & Yoon (2020), the effective learning strategies are crucial for academic success and achieving learning outcomes. Research also shows that high-quality instruction and active learning contribute significantly to student achievement. Besides that, quality learning experiences are essential for developing skills necessary for future careers. Students also need to know the importance of experiential learning and critical thinking skills in preparing for the workforce (Carter, 2021).

The curriculum, a cornerstone of education, refers to the organized set of courses, content, and learning experiences designed to achieve specific educational outcomes within a given field of study. Curriculum will cover for the subjects, methodology of teaching, assessments and also the goals for education (Smith & Doe, 2023). By reviewing the curriculum, educators can identify areas where structural analysis concepts are introduced and reinforced throughout the program. It focuses on aligning educational content with desired learning outcomes and adapting to the needs of students and society. Effective curricula integrate various teaching methods and assessment strategies to support student learning (Schwab, 2020). The curriculum is crucial for shaping student learning experiences and outcomes. Recent research highlights that a well-structured curriculum can significantly enhance student achievement and engagement (Cunningham, 2021).

The objective for this study are to analyze the performance of students enrolled in the Basic Structural Analysis course over three semesters which were 20212, 20222, and 20224. There are two (2) Course Outcome (CO) and two (2) Program Outcomes (PO) in this course. CO1 is to compute forces and stability in statically determinate structures and CO2 is to evaluate structural analysis problems in statically indeterminate structures. PO1 is to apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in DK1 to DK4 respectively to wide practical procedures and practices. PO2 is to identify and analyze well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity. By analyzing CO and PO data, the research aims to identify trends in student performance, evaluate the effectiveness of various teaching methods, and understand the relationship between student feedback and

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learning outcomes. Besides that, the achievement in test and the percentage of student scoring more than 50% also been measured.

Literature Review

Basic Structural Analysis is a foundational course in civil engineering that involves the study of methods to determine the effects of loads on physical structures and their components. It includes understanding the principles and techniques necessary to analyze and ensure the stability, strength, and rigidity of structures. According to McCormac (2021), Basic Structural Analysis introduces fundamental concepts such as equilibrium, compatibility, and material behavior. It covers methods like the force method, displacement method, and matrix analysis to solve for internal forces and displacements. This course equips students with the skills needed to analyze various structural elements, including beams, trusses, and frames. It is essential for ensuring that structures can withstand applied loads without failure (Hibbeler, 2022).

To ensure student understanding for every topic been teached, assessment need to be conducted. As shown in Figure 1, students notes were given in order to enhance students understanding. Assessment refers to the process of evaluating, measuring, and documenting students' learning, skills, and performance. It involves various methods and tools to determine how well students have achieved learning objectives and outcomes. Assessments are designed to provide feedback on student learning, inform instructional decisions, and support student development. There are formative assessments (ongoing assessments to guide learning) and summative assessments (evaluations at the end of an instructional period) (Guskey, 2020). According to Hattie & Timperley (2020), these are ongoing assessments designed to monitor student learning and provide feedback during the instructional process. Formative assessments help identify areas where students need improvement and guide future teaching strategies. While Guskey (2020) state that summative assessments are typically administered at the end of an instructional period to evaluate and summarize student learning. They are often used for grading and determining if students have met the learning objectives.

Based on these assessments, data from CO and PO can be obtained and student performance for Basic Structural Analysis can be seen. Student performance refers to the measurement of students' abilities, knowledge, and skills as demonstrated through various assessments and evaluations. It encompasses a range of metrics, including grades, test scores, project outcomes, and overall academic achievements. Effective assessment practices that provide timely and constructive feedback are crucial for improving student performance. Feedback helps students understand their strengths and areas for improvement, thereby influencing their future performance (Hattie & Timperley, 2020).

According to Premalatha, K. (2019), the Course Outcomes (CO) are specific, measurable statements detailing what students should know and be able to do by the end of a course. These outcomes are aligned with the broader Program Outcomes (PO) and are assessed through various methods such as exams, projects, and assignments. COs focus on the immediate learning objectives of a particular course. While Dandin, S. et al. (2024) stated that Program Outcomes are broader statements that describe the knowledge, skills, and competencies students are expected to achieve by the end of an educational program. POs ensure that graduates are prepared for professional practice and further education. They encompass a range of abilities, including technical skills, critical thinking, communication, and ethical reasoning.

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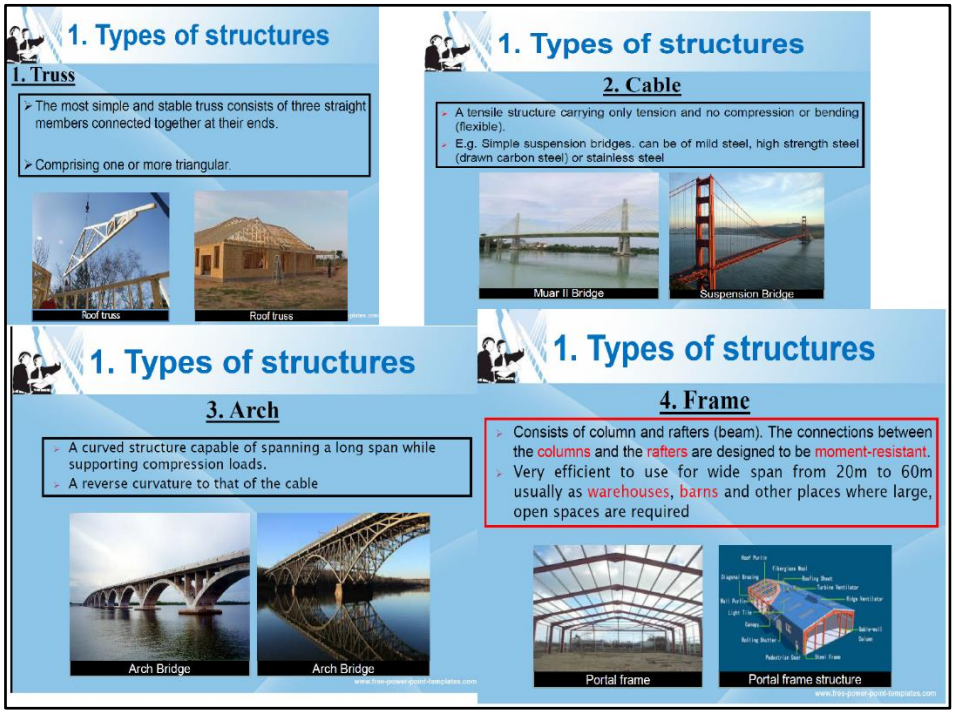

Figure 1: Example of Notes of Basic Structural Analysis

Methodology

As stated in syllabus content, Basic Structural Analysis for Diploma students in UiTM is a 3-credit hour course. This course description contains many topics which are introduction to types of structures, internal forces and joint of statically determinate structures: pin jointed trusses, three-hinged arches, portal frame, suspension cable and analysis of indeterminate beam using moment distribution method. All these topics must be delivered to students within 1 semester which contains 14 weeks. Each topic in this course will be allocated time based on its requirements. The introduction topic will be covered in just 1 week, while the topics of cable, arch, and frame will each be covered in 2 weeks. The topics of truss and MDM will be covered in 3 weeks and 4 weeks, respectively. Every week students will be joining 3 hours of lecture sessions and 1 hour of tutorial sessions.

During the 14-week lecture period, students will be assessed to evaluate their understanding of the assigned topics. The assessment accounts for 40% of the total grade, with 30% allocated to tests and 10% to assignments. The remaining 60% of the grade is based on the final exam. 75% of the overall grade comes from CO1 and PO1, which is included in all three assessments given to students. The remaining 25% is from CO2 and PO2 which can be found in Assignment and final examination.

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Table 1: Mapping CO-PO with Assessments

Assessment	CO1-PO1	CO2-PO2
Test	30%	-
Assignment	5%	5%
Final Examination	40%	20%

After students have completed the exam and the final grades have been generated, these scores will be entered into the system provided to analyze various required data, including CO and PO data. From this, the strengths and weaknesses of students can be identified according to the required CO and PO. Thus, improvements can be made in addition to the surveys conducted with students intermittently throughout the lecture sessions.

Results and Discussion

The data in this study were collected from the assessment by students across three semesters (20212, 20222 and 20224). Students are given three (3) types of assessment as stated earlier in methodology which are assignments, test and final examinations. Assessments provide essential feedback to both educators and students, informing instructional practices and learning progress (Black & William, 2023). According to Johnson (2023), assessments are critical to evaluate student understanding and proficiency in subject areas, which can impact future learning opportunities. Using a range of assessment methods, including quizzes, exams, projects, and practical assignments, enables educators to evaluate student understanding from multiple angles. Additionally, aligning assessments with course outcomes ensures they accurately measure students' mastery of structural analysis concepts.

Student Performance According to Grades

Table 2 shows the overall performance of this course based on student grades across 3 semesters. The total number of students in semester 20222 is the highest compared to the other two semesters. Given that semester 20222 had the largest number of students, the number of failures was also the highest, as well as the distribution of grades. However, in semester 20212, there were no students who failed, despite the number of students being higher compared to semester 20224. This may be due to the assessments given and the teaching techniques used being less effective during that semester, where a significant change occurred from online learning to offline learning. Consequently, students needed to adapt to the new situations. According to Garrison & Vaughan (2020), studies indicate that online learning can impact student engagement and performance differently compared to traditional offline learning. Online learning often requires different strategies for maintaining engagement, and students may face challenges adapting to new formats.

Table 2: Overall Student Performance per Semester

Semester	A+, A, A-	B+, B, B-	C+, C	C-, D+, D	E	F	Total	% Fail
20212	28	12	1	0	0	0	41	0
20222	32	47	15	3	6	0	103	9
20224	28	4	0	1	0	0	33	3

Figure 2 shows a significant drop in performance with less than 45% in semester 20224 compared to the previous two semesters which are more than 80% of test score. This test contributes 30% to the overall grade. In the 20212 and 20222 semesters, this 30% assessment

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was conducted online, where students were given a week to complete and submit the assignment. This method indeed helped students by allowing them to use various resources such as books, notes, and online class recordings provided in order to complete that assessment.

However, the situation was different in the 20224 semesters, where this 30% assessment was conducted physically, similar to traditional exams. Students had to take the test offline and were given a two-hour period to submit it. This method truly tested the students' understanding and memorize the formula needed as they no longer had access to additional resources. This was found to be a major contributing factor to the significant drop in test scores during the 20224 semesters.

Recent research has identified several factors that can contribute to a decline in student performance. The effectiveness of teaching methods plays a crucial role in student performance. Recent research indicates that misalignment between teaching strategies and students' learning needs can hinder performance (Morris & Thomas, 2022). Lee and Tan (2023) also testified the transition back to in-person learning revealed a significant drop in student performance especially in subjects that required hands-on practice and direct interaction. The implementation of hybrid learning models, which combine both in-person and online learning, as a response to the challenges posed by the COVID-19 pandemic (Ahmad, S. & Rahman, N., 2023).

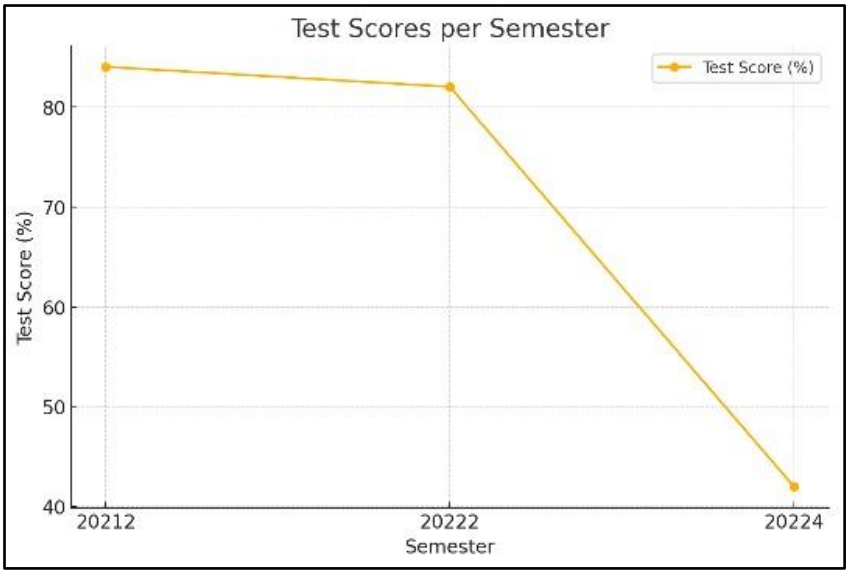

Figure 2: Test Scores per Semester

Course Outcome (CO) Attainment

Figure 3 illustrates the average attainment for CO1 and CO2, highlighting a significant decline in CO performance in semester 20224. In semester 20212, the average CO attainment was above 80 for CO1 and 60 for CO2, with a slight decrease observed in semester 20222. As shown in the same figure, CO2 contribute to less attainment compared to CO1. Cueto and González (2018) stated that indeterminate structures involve more complex calculations and concepts compared to determinate structures. This complexity can be overwhelming for students, especially if they lack a strong foundation in basic structural analysis. Students often find it difficult to grasp theoretical concepts without practical application. The lack of hands-on experience with real-world examples can slow down their understanding. If assessments do

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not accurately reflect students' understanding or if they are perceived as too challenging, this can demotivate students and negatively impact their performance (Lee & Tan, 2022). This decline may be also attributed to a lack of active learning, which has been shown to improve student performance. Active learning techniques are known to enhance student engagement, comprehension, retention, and knowledge transfer more effectively than traditional passive learning methods (Michael, 2006).

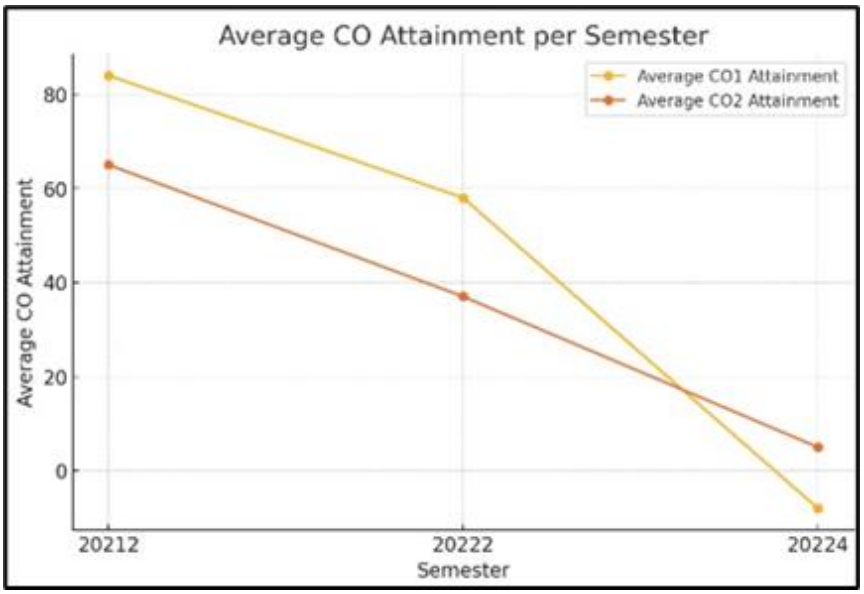

Figure 3: Average CO Attainment per Semester

Program Outcome (PO) Attainment

Figure 4 illustrates the average program outcome attainment for PO1 and PO2. As with CO, there is a notable decline in PO1 during semester 20224. Both CO and PO demonstrate a similar pattern of decrease. In addition to the lack of active learning, insufficient problem-solving activities may also contribute to the drop in student performance in basic structural analysis. Problem-solving activities provide students with challenging problems or case studies that require critical thinking and analysis. Engaging with real-world scenarios helps students develop problem-solving skills, decision-making abilities, and a deeper understanding of complex concepts (Hmelo-Silver et al., 2007).

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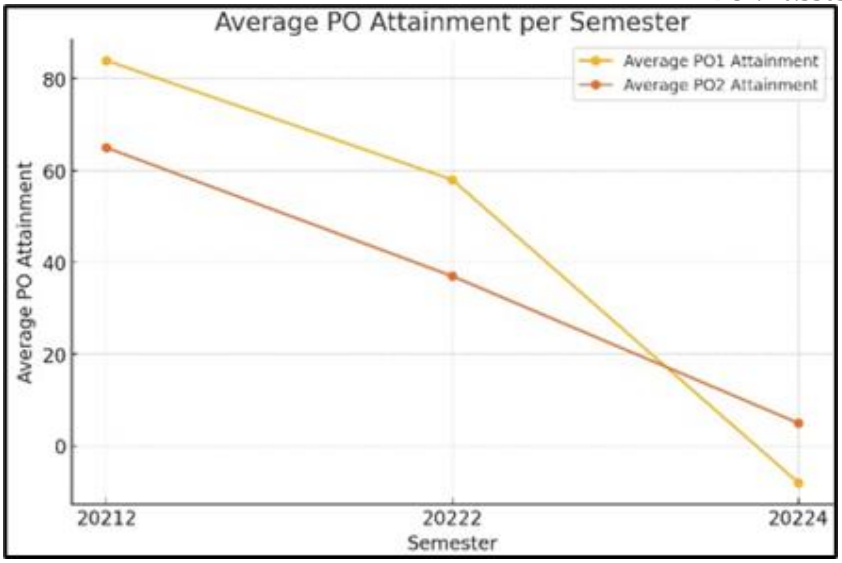

Figure 4: Average PO Attainment per Semester

Figure 5 shows the data on the number of students achieving over 50% for PO1 and PO2. Generally, PO1 has a higher number of students exceeding 50% compared to PO2. However, for semester 20224, which shows lower performance in both PO1 and PO2. It might come from the shift from online to offline learning poses challenges for both students and educators. Students may need time to readjust to face-to-face interactions and classroom dynamics, while educators may need to adapt their teaching methods to fit the offline environment (Rienties & Toetenel, 2021). As stated from Zhao et al. (2020), mixed outcomes regarding learning effectiveness and student satisfaction with online versus offline learning. Some studies suggest that online learning can be as effective as offline learning when well-designed, but there are concerns about the quality of interactions and practical experiences in a virtual setting.

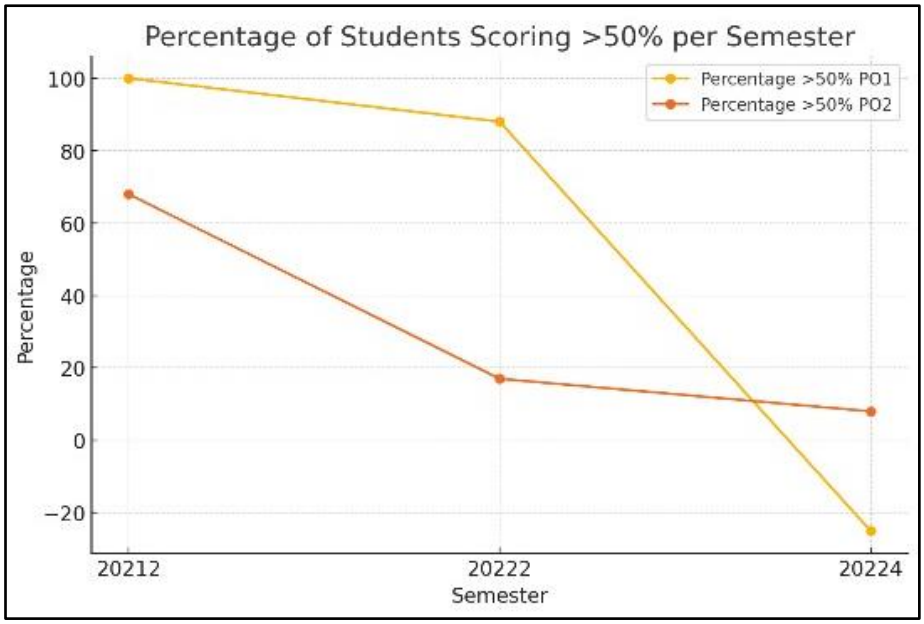

Figure 5: Percentage of Students Scoring

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Conclusions

This study aims is to analyse the performance of students enrolled in the Basic Structural Analysis course over three semesters: 20212, 20222, and 20224. The findings of this study will contribute to the ongoing efforts to refine educational strategies in the Basic Structural Analysis course, ensuring that it continues to meet the needs of civil engineering students and prepares them effectively for their professional roles. This research underscores the significance of foundational courses in the civil engineering curriculum and the importance of adapting teaching methodologies to foster better learning outcomes and overall student success.

Several strategies can be implemented to improve student performance in Basic Structural Analysis. Smith et al. (2021) and Shahril, A. M. et al. (2024) mentioned that incorporating active learning strategies can enhance student engagement and understanding. Techniques such as problem-based learning (PBL) and interactive simulations help students apply concepts in practical scenarios, which improves their grasp of structural analysis principles. Besides active learning method, by providing timely and detailed feedback on assignments and assessments helps students identify their strengths and areas for improvement. Research shows that constructive feedback is crucial for student development and performance enhancement (Hattie & Timperley, 2020). Implementing frequent formative assessments to gauge student understanding and adapting teaching methods based on assessment results can also help address learning gaps. Regular assessments provide insights into student progress and help lecturer to better meet student's needs (Guskey, 2020).

A study by Shahril, A. M. et al. (2024) highlighted the positive impact of digital technology on student motivation, knowledge development, and perceived effectiveness. By integrating digital tools into the curriculum, educators can enhance student engagement and learning outcomes besides by creating active learning environments. It is where students participate in group projects, peer teaching, and interactive sessions can improve their academic performance. These environments encourage collaboration and critical thinking, which are essential for student success.

Considering that students nowadays are truly exposed to and more interested in games, this might be introduced. Implementing gamification in educational settings has been shown to significantly boost student motivation and academic performance. Gamification involves incorporating game elements into learning activities, which can make the learning process more engaging and enjoyable for students (Jaramillo-Mediavilla et al., 2024).

Regardless of the methods employed to enhance student performance in this matter, it is essential for students to cultivate an interest and dedicate significant effort to their studies. This commitment not only leads to academic success but also fosters personal growth and excellence.

Acknowledgements

The authors would like to express their gratitude and thanks to UiTM Cawangan Pulau Pinang for the support.

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EISSN: 2637-0905
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