Transforming Individual to Collaborative Endeavors: A Comparative Analysis on Student Achievement and PO Attainment in Soil Engineering Laboratory Course

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ABSTRACT

This paper investigates the impact of individual versus collaborative assessments methods on student academic performance and Program Outcome (PO) achievement in the Soil Engineering Laboratory course at Universiti Teknologi MARA Johor Pasir Gudang campus that pursuing diploma studies. Traditionally assessed through individual projects, the course shifted to a group-based project in subsequent semesters to foster teamwork, communication and problem-solving skills in line with Outcome-Based Education (OBE) principles. By analyzing student performance data from four consecutive semesters (20232 – 20244), the study examines variations in PO4 attainment and overall grade distribution among students that undertake this course. Findings reveal that while both assessment approaches support high academic achievement, a significant decline in PO4 attainment during the group assessed semester (20244) whereby highlights the challenges in collaborative learning, such as unequal participation and engagement issues. The results underscore the need for balanced assessment strategies that integrate both individual and group elements to maximize learning outcomes. Recommendations include incorporating peer/self-assessment and reflective practices to enhance fairness, accountability and the effectiveness of collaborative tasks. This research contributes to ongoing efforts to align pedagogical strategies with OBE frameworks in engineering education.

Keywords: Collaborative learning, Engineering education, Outcome-Based Education (OBE), Program Outcomes (PO), Soil Engineering Laboratory

INTRODUCTION

Background of Study

The assessment of engineering skills and knowledge is an essential part of engineering education, both theoretically and practically. The development of learning and competencies has been a significant challenge in undergraduate (Aristovnik et al.,2020). Providing a professional engineering education requires preparing students with technical skills, soft skills, and the ability to handle modern tools that come with a variety of contemporary challenges that will be encountered after graduation. Tseng,et al (2016), highlighted that various teaching and assessments methods such as collaborative teaching and project-based learning approaches have been implemented to improve critical thinking skills, teamwork, communication, problem solving, and lifelong learning skills in students.

Agreed by Stoicoiu, (2017), stated that collaborative learning and group-based projects now play a more and more important role in modern engineering education as employers increasingly demand teamwork skills. However, Callin mentioned in their study, there are still concerns regarding its potential drawbacks, among those are uneven work distribution when working in teams, disengagement from students from other students or from the project itself, and dishonest means to develop the project. As a result of the passive role that the student plays, it can negatively impact the overall learning outcome in any engineering college level course.

Recent studies have been shown the benefits of diversifying assessment approaches. Lenkauskaitė et al. (2021) mentioned that involving students to participate in the assessment gives the opportunities for students to be aware of their role in the evaluation process that provides a valuable learning experience. Individual assessments, as noted by Yan et al. (2023), enable students to identify their strength and weaknesses by allowing the students to adjust learning strategies accordingly.

According to Stančić (2021), individual assessment and peer assessment, both of which serve an important role in determining the qualifying student achievement and enabling students to develop lifelong learning skills. On any assessment evaluation, it is the lecturer's responsibility to figure out how current learning and assessment activities may be beneficial for students' outcome (Yan et al, 2023). Azmy & Mat Isa, (2025) demonstrated that integrating alternative assessment with design thinking, supported by a Performance Criteria Matrix (PCM) aligned to ETAC 2020 which significantly improved students' abilities in problem analysis, use of modern tools, teamwork and project management.

In response to these challenges, various research efforts in engineering education have explored strategies to make programme outcomes assessment more efficient, aiming to minimise the time and resources required without compromising its effectiveness (Liew, Hamzah, et al., 2020; Liew, Puteh, et al., 2020). Despite these advancements, limited research has examined the transition from individual to collaborative assessment within laboratory-based engineering courses, particularly in soil laboratory education. Given the hands-on and applied nature of such courses, investigating how assessment mode influences student achievement and Programme Outcome (PO) attainment can yield critical insights for enhancing both learning and accreditation alignment.

Statement of Problem

The Soil Engineering Laboratory course is available to fourth-semester students pursuing a Diploma in Civil Engineering at UiTM. It is a 1.0 credit hour course, and it is considered a core and fundamental subject. Previously, in the semesters of 20232 (March 2023 – August 2023) and 20234 (October 2023 – February 2024) assessments were made on an individual basis, whereas semester 20242 (March 2024 – August 2024) and 20244 (October 2023 – February 2024) to current, group assessments were conducted to impart better understanding and develop collaboration skills. This subject previously focused primarily on laboratory-based courses, like soil laboratory engineering, which limit opportunities to develop important collaborative skills. Despite individual learning's benefits, it may not fulfil the demands of outcome-based education (OBE), which focuses on achieving program outcomes (POs) like teamwork, communication, and problem solving. Hence, it is essential to evaluate whether transforming individual lab activities into collaborative ones can enhance students' academic performance as well as their PO achievement.

Objective of Study

This study is undertaken to explore and compare the academic performance of the students enrolled in the Soil Engineering Laboratory course when evaluated through two different assessment approaches which are by individual assessment and collaborative assessment. The comparative analysis aims to identify how each approach influences student achievement, learning engagement and skill development. Furthermore, the study evaluates the impact of collaborative learning on the attainment of specific Programme Outcome (POs) as outlined in the Engineering Accreditation Council (EAC) framework, particularly in the domains of teamwork, communication and problem solving. By examining the relationship between the assessment method and PO attainment, this research intends to generate the evidence-based recommendation for improving the instructional design and assessment strategies in engineering laboratory courses. The findings are expected to contribute to the ongoing discourse on best practices in engineering education, particularly in balancing technical proficiency with essential soft skills that are critical for graduate employability and professional success.

LITERATURE REVIEW

In an outcome-based education (OBE) framework that has been practiced in Malaysian engineering programs, it is essential that assessments accurately reflect the attainment of specific Program Outcomes (POs) such as problem analysis, effective communication, teamwork and lifelong learning. According to Biggs (2003), the constructive alignment between learning outcomes, instructional activities and assessment tasks ensures students are evaluated meaningfully and rightfully. Within university-level natural resource programs, active, student-focused, and collaborative learning methods are increasingly implemented to cultivate skills aligned with professional career demands. Such approaches seek to enhance student engagement, develop higher-order critical thinking and problem-solving abilities, and foster meaningful peer learning experiences (Brown & Bomke, 2020; Prince et al., 2013). On the other hand, individual project assessments promote a more transparent and accountable learning process where it can encourage students to take ownership of their work, reflect on their performance and independently develop the student skills which directly contribute to lifelong learning and another critical outcome.

Previous study shows that fostering self-directed learning necessitates cultivating specific attitudes and behaviours in both students and the broader higher-education establishment (Esmaeil et al., 2024). The study conducted by Wee et al, (2024) highlights the effective implementation of Outcome-Based Education (OBE) in Malaysian academic programs. The study underscores the significance of aligning assessment strategies with OBE principles to meet the evolving expectations of the engineering profession. In the Malaysian context, several studies have examined the relationship between assessment design and the attainment of specific Program Outcomes under the Engineering Accreditation Council (EAC) standards. For instance, (Liew et al., 2024) identify challenges and propose sustainable assessment practices aiming to strengthen assessment of investigative outcomes such as PO4 in engineering programmes.

Past Studies on Individual vs. Group Work

Research shows that using mixed-ability collaborative learning groups can significantly enhance academic development, as the diverse backgrounds and skills of group members serve as valuable resources that contribute to deeper learning (Järvelä & Järvenoja, 2011). The American Association of Colleges and Universities (AAC&U) describes collaborative learning as an educational practice that encourages students to work and solve problems together while deepening their own understanding by seriously engaging with diverse perspectives and experiences (AAC&U, 2022). Research has consistently demonstrated that this approach enhances critical thinking, perseverance, motivation, and academic performance (Crouch & Mazur, 2001; Wang et al., 2017). Many education experts agree that both individual and collaborative group work play important roles in effective teaching and learning.

According to Ashikullah et al. (2024), the effectiveness of each approach depends on several factors, including the specific learning objectives, the nature of the task, and the characteristics of the learners. Individual learning allows students to work at their own pace, enabling them to focus on personal strengths and address individual challenges. In contrast, group learning involves collaboration among peers and encourages the exchange of ideas, mutual support, and shared problem-solving. Group study can take various forms, ranging from small peer groups to larger collaborative teams. Research by Webb et al. (2018) found that students who participated in group study demonstrated higher academic achievement and increased motivation compared to those who studied independently.

Marzano & Kendall, (2007) propose a revised taxonomy of educational objectives that expands on Bloom's framework by incorporating three domains of knowledge such as informational, mental procedures, and psychomotor procedures and six hierarchical levels of cognitive processing which includes retrieval, comprehension, analysis, knowledge utilization, metacognitive, and self-system. This model not only facilitates the classification of learning objectives and the design of assessments, but also emphasizes the importance of crafting assessments that align with various levels of cognitive demand and knowledge types, thereby enhancing the evaluation of investigative skills essential for engineering education.

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Collaborative learning involves many interacting factors within a group (Dick et al., 2022). Moore et al. (2019) investigated the impact of using video reflection and guided discussions within diverse collaborative groups. Their findings showed that all students spent more time focused on tasks, and there was greater involvement from students of varied backgrounds and abilities. These students also engaged more actively in meaningful, content-related discussions. This approach allows students to benefit from the collaborative environment for skill-building while reinforcing personal responsibility and deeper understanding through individual assignments.

A comprehensive review of past research reveals that both individual and collaborative learning approaches hold distinct yet complementary roles in fostering student achievement, skill development, and engagement. When implemented strategically taking into account learner characteristics, task complexity, and desired outcomes, these approaches can create a balanced educational environment that not only strengthens subject mastery but also cultivates essential professional competencies such as critical thinking, communication, and lifelong learning, ultimately aligning with the overarching principles of Outcome-Based Education.

MATERIALS AND METHODS

Soil Engineering Laboratory (ECG263) is a hands-on course specifically designed for second-year Diploma in Civil Engineering students. As a fully laboratory-based course, it emphasizes the application of theoretical knowledge gained in earlier semesters through experiments, testing, and data analysis related to soil behaviour and properties. This course is a pre -requisite subject which requires students to successfully pass the soil mechanics subject which is typically taken in semester 3 before enrolling in ECG263 in semester 4. This pre-requisite ensures that students have a solid theoretical foundation to understand the tests they need to perform in the laboratory. This course does not include a final examination, instead all marks are determined through continuous assessment marks.

The assessment breakdown for ECG263 course is structured to evaluate students through three main categories which include practical tests, laboratory report and project. The detailed assessment marks are listed in Table 1.

Table 1: Course assessment for ECG263

No	Assessment	Assessment Marks (%)
1	Practical Tests	50
2	Lab Report	10
3	Project	40

The practical test includes two practical tests to assess students' ability to conduct experiments accurately without guidance. Practical test is assessed individually based on the selected experiment. Each test contributes 25% marks to the overall grade. Additionally, 10% of the assessment is allocated to a group submission of laboratory reports. This report is used to assess technical writing skills by grouping submission. For the project assessment, students are assigned to a task that addresses typical problems in civil engineering practices. The project carries a significant 40% of total course marks. This paper will primarily concentrate on the evaluation of the project component.

The project is scheduled to run over a five-week duration, providing students with ample time to plan, execute and present their work. At the beginning of the project, the lecturer will brief the overall purposed of the project to ensure that all students have a clear understanding before initiating their work. This mini project is designed to emphasize on student's ability to discover and conduct certain soil engineering tests based on related tasks to be carried out. As part of the project, students are required to prepare a detailed technical report and produce a video presentation. The evaluation mark is based on Table 2. By completing this task, students should be able to describe and elaborate soil engineering procedures to evaluate soil characteristics and effectively address engineering challenges by applying relevant engineering practice.

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Table 2: Element to assess for mini project

ECG263 Mini Project Marks			
No	Element to assess		Marks
1	Report	Introduction	/2
2		Methodology	/4
3		Findings	/4
4		Discussion	/4
5		Conclusion	/4
6		References	/2
No	Element to assess		Marks
1	Video presentation	Introduction	/1
2		Methodology	/4
3		Findings	/3
4		Discussion & Conclusion	/4
5		Delivery & Presentation	/4
6		Content & Organization	/1
7		Course Contribution	/3
Total Marks			40%

Table 3 presents student's enrolment for four (4) semesters, categorised by intake type. The first intake semesters (20232 and 20242) have significantly higher numbers of students compared to second intake semesters (20234 and 20244).

Table 3: Total number of students for different intake

No	Semester	No. of students	Intake
1.	20232 (March 2023 – August 2023)	168	First intake
2.	20234 (October 2023 – February 2024)	9	Second intake
3.	20232 (March 2024 – August 2024)	150	First intake
4.	20244 (October 2024 – February 2025)	27	Second intake

While Table 4 outlines the type of assessment conducted in each semester. For semester 20232 and 20234, the assessment was based on individual project whereas group-based project was implemented in semesters 20242 and 20244. Due to variation in assessment methods between 2023 and 2024, student grades also differed, which will be discussed in a subsequent section.

Table 4: Types of assessment by semester

No.	Semester	Types of assessment
1.	20232 (March 2023 – August 2023)	Individual Project
2.	20234 (October 2023 – February 2024)	
3.	20232 (March 2024 – August 2024)	Group-Based Project
4.	20244 (October 2024 – February 2025)	

RESULTS AND DISCUSSION

Program Outcome 4 (PO4), which typically pertains to a student's ability to investigate well defined engineering

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problems using appropriate research-based knowledge and methods, is a critical metric in assessing analytical and investigative competencies. Figure 1 displays the data collected across four consecutive semesters—20232, 20234, 20242, and 20244—reveals both stability and a point of concern in student performance related to this outcome. In the initial three semesters ,20232 to 20242, PO4 attainment remained relatively stable, showing a positive increment from 74% in 20232 to a peak of 78% in semester 20234, followed by a slight decrease to 77% in semester 20242.

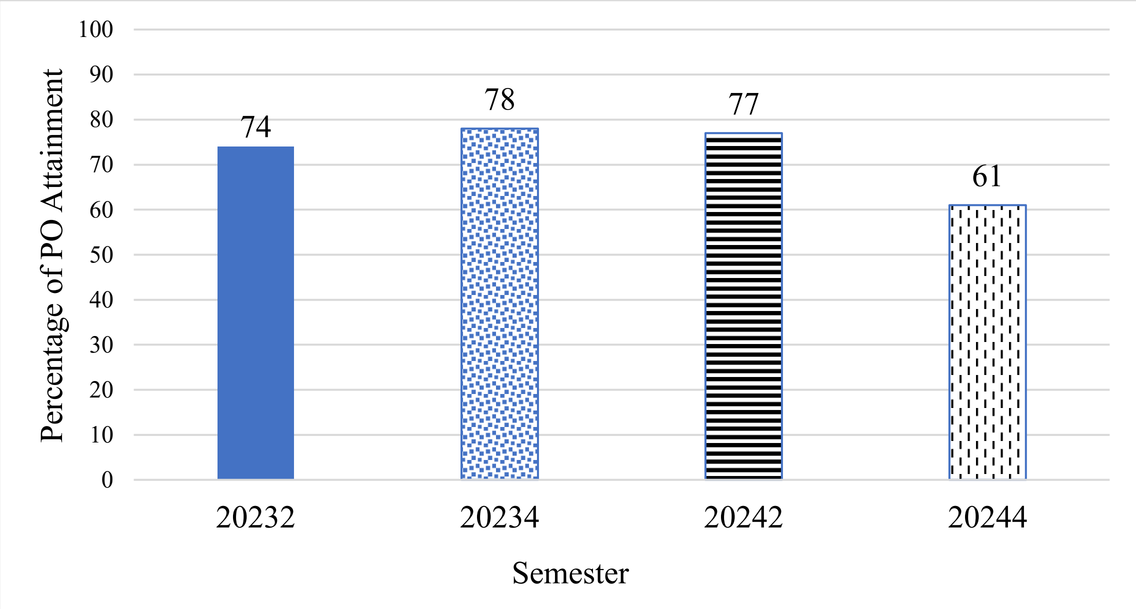

Figure 1: Average CO2/PO4 attainment for four consecutive semesters

This consistency suggests that students were generally demonstrating strong investigative skills and benefitting from a structured laboratory environment. The rise in PO4 attainment during 20234 may be attributed to enhanced instructional strategies, better-aligned assessment rubrics, or the maturation of the course design. However, a notable gap occurs in semester 20244, where PO4 attainment sharply declines to 61%, marking a significant 16% drop from the previous semester. This decrement raises important pedagogical questions. The downturn may be attributed to challenges inherent in group-based assessments, such as unequal participation, coordination issues, and peer dynamics. Research by Adesina et al. (2022) highlights that while peer assessment can enhance engagement, it also introduces complexities in managing group work effectively. Additionally, Freeman et al. (2014) found that active learning environments, often involving group work, can improve student performance, but the benefits are contingent on proper implementation and student engagement. This downward trend indicates the need for a closer examination of the instructional approach and assessment implementation during semester 20244. Introducing peer assessments, providing clearer guidance on investigative expectations within group tasks, or integrating reflective components could help restore and enhance PO4 attainment in future offerings.

The grade achievement distribution over four semesters is shown in Figure 2. It shows a consistent pattern of high academic performance. In semesters 20232 and 20242 (first intake students), the majority of students received grades in the A or A- range which indicates strong performance.

Semesters 20234 and 20244 had fewer students (second intake students) but showed similar trends. There was no grade below B- in most semesters, and only one failing grade (F) was recorded throughout the entire dataset. This suggests that both individual and group assessments can lead to high academic achievement, but the structure and context of these assessments may influence student performance.

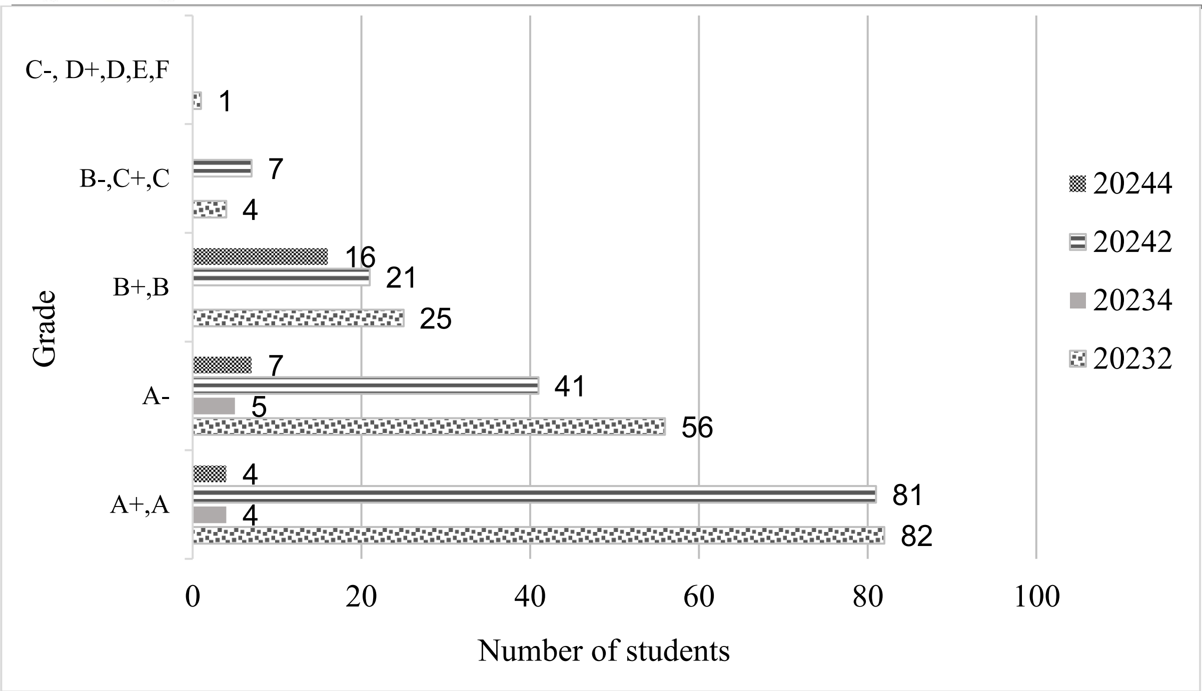

Figure 2: Student's grade achievement

Individual assessments often provide a clear reflection of a student's understanding and capabilities. The data from semesters 20232 and 20234, where individual assessments were prevalent, show a concentration of high grades, particularly in the A+/A and A- categories. This could indicate that students perform well when evaluated on their own merit. However, the smaller cohort in 20234 may limit the generalizability of this observation.

Group assessments can foster collaboration and collective problem-solving skills. The data from semester 20242, with a larger group assessment cohort, shows a similar trend of high grades, suggesting that students can achieve strong academic outcomes through collaborative efforts. Subasman (2024), revealed a significant correlation between effective group collaboration and enhanced learning outcomes was factorized by positive interaction, effective conflict management, and equitable task distribution contributed to improved group performance. However, the varied grade distribution in semester 20244 indicates that group dynamics and individual contributions can affect the overall performance.

These findings suggest that a combination of both individual and collaborative work in Soil Engineering Laboratory course can provide the best of both worlds, promoting both skill development and individual mastery. Thus, it is particularly relevant in the context of ECG263 subject, a course offered under the Faculty of Civil Engineering at Universiti Teknologi MARA (UiTM) Pasir Gudang, Johor which emphasises the development of both technical and soft skills aligned with national engineering education standards (Engineering Accreditation Council, 2020).

A chi-square test of independence was conducted to examine whether the distribution of students' grades differed significantly across the four semesters. The chi-square test was selected because both variables under investigation are categorical, semester and grade classification, making it an appropriate method for determining whether grade performance was associated with the semester. The analysis indicated a statistically significant difference in grade distributions across semesters, $\chi^2(12) = 44.10$, $p < .001$, suggesting that students' academic performance varied significantly between semesters. The significant differences in grade distribution across semesters suggest that students' academic performance varied over the study period. This variation coincided with changes in the average PO4 attainment, where semesters with higher PO4 attainment (20232–20242: 74–78%) generally recorded a greater proportion of Grade A and Grade A− students than Semester 20244, which had the lowest PO4 attainment (61%) and a markedly lower proportion of Grade A students. This pattern indicates that stronger attainment of PO4, which reflects students' competence in investigation and problem-solving, may be associated with improved academic performance. However, because the present analysis used semester-level average PO4 attainment rather than individual student PO4 scores, the observed association should be interpreted as descriptive rather than causal. Future studies using student-level PO attainment data could employ correlation or regression analyses to determine whether higher PO4 attainment significantly predicts better academic achievement.

CONCLUSION

In conclusion, this study demonstrates that both individual and collaborative assessment methods offer distinct benefits in the context of engineering education. Individual assessments promote accountability, self-directed learning, and provide a clear indication of a student's capabilities. Conversely, group-based assessments encourage the development of essential soft skills such as teamwork, communication, and problem solving, which are vital in professional engineering practice. However, the observed decline in PO4 attainment during the group-assessed semester suggests that collaborative learning must be carefully structured to avoid common pitfalls such as uneven workload distribution and lack of engagement. These findings highlight the importance of adopting a balanced assessment strategy that integrates both individual and group elements to maximize student learning outcomes. For future research, it is recommended to conduct a long-term study to see how this assessment method affects graduates' skill development and their chances of getting a job. Moreover, incorporating peer and self-assessment tools could enhance fairness and individual accountability in group projects. Qualitative methods such as interviews and student reflections may provide deeper insights into learner experiences, while expanding the study across other engineering courses could validate its broader applicability. Additionally, exploring the role of digital collaboration tools may offer innovative solutions to optimize group dynamics and performance. Collectively, these efforts will contribute to refining pedagogical strategies that align with Outcome-Based Education (OBE) principles and meet the evolving demands of the engineering profession.

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