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Civil Engineering Students' Learning Outcomes and Performance Trends: A Multi- Assessment Evaluation in a Contracts and Estimation Course.

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KEYWORDS
Contracts and Estimation; Outcome-Based Education; CLO/LOD Attainment; Continuous Assessment; Predictive Modelling; Learning Outcomes; Engineering Education; Malaysia.
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ABSTRACT
This study evaluates civil engineering students' performance in a Contracts and Estimation course within Malaysia's Outcome-Based Education (OBE) framework, focusing on cognitive, affective, and psychomotor learning outcomes. Performance records from 53 students were analyzed using descriptive statistics, correlation analysis, multiple regression, and CLO/LOD attainment mapping to examine (i) performance trends across assessment components, (ii) the predictive value of continuous assessments for final examination scores and overall achievement, and (iii) attainment of CLOs and LODs relative to the institutional benchmarks. Results revealed consistently high attainment in affective and psychomotor domains (~90–95%), but comparatively lower attainment in the cognitive domain (~65%). Regression analysis showed that continuous assessments strongly explained total course performance ($R^2 \approx 0.90$) but only moderately explained final examination outcomes ($R^2 \approx 0.50$). These findings underscore the need for improved alignment in assessment design, greater scaffolding of cognitive learning, and strengthened continuous quality improvement (CQI) practices. The study contributes empirical evidence to engineering education research and offers actionable recommendations for enhancing balanced learning outcomes in civil engineering programmes..

1. INTRODUCTION

Engineering education in Malaysia has seen widespread adoption of Outcome-Based Education (OBE), requiring alignment of Programme Learning Outcomes (PLOs), Course Learning Outcomes (CLOs), and assessments to ensure graduates are competent across cognitive, affective, and psychomotor domains (Engineering Accreditation Council [EAC], 2024). The implementation of OBE is closely tied to accreditation requirements set by the Malaysian Qualifications Agency (MQA) and the Engineering Accreditation Council (EAC), which mandate that engineering programmes produce graduates with not only strong technical knowledge but also essential professional and transferable skills. In this context, teaching and assessment must be explicitly mapped to learning outcomes, ensuring constructive alignment between intended outcomes, instructional strategies, and evaluation methods. This principle of constructive alignment, widely recognized in higher education globally, emphasizes coherence across curriculum design to enhance meaningful learning (Biggs, Tang, & Kennedy, 2022). For Malaysia, the integration of OBE reflects global trends in engineering education, where emphasis is placed on student-centred learning, measurable competencies, and continuous quality improvement, ultimately supporting the national agenda of producing industry-ready graduates capable of meeting the demands of a rapidly evolving engineering and construction sector (Tuselim, Muhammad, & Chau Mai, 2020; Nurdin, Suhaimi, Nazwa, Abd Aziz, & Zamri, 2024).

Contracts and Estimation is a core course in civil and construction engineering education, designed to prepare graduates for the complex demands of the industry. The course equips students with essential competencies in cost estimating and contract administration, linking academic training with real-world project management practices. Studies have identified cost estimation as a critical factor influencing project success (Sadikoglu & Demirkesen, 2025). An integrated understanding of technical and legal dimensions is essential for effective contract administration (Kim, Shin, Kim, & Kwon, 2025). This course, through its focus on cost estimation and contract administration, equips graduates with a strong foundation for handling the technical and managerial dimensions of construction projects.

This study addresses concerns over integrating legal and technical competencies in civil engineering education by evaluating student performance in a Contracts and Estimation course. It analyzes performance trends across assessments, examines the predictive power of continuous assessments, and evaluates CLO and LOD attainment against institutional OBE standards derived from the Malaysian Qualifications Framework (Malaysian Qualifications Agency [MQA], 2024) and adapted to the institution's curriculum. For clarity, the terms institutional OBE standards and institutional benchmarks in this study both refer to MQF-derived requirements adapted at the institutional level.

2. LITERATURE REVIEW

Integrating Theory, Legal Frameworks, and Practice in Contracts and Estimation

Research highlights that effective learning in Contracts and Estimation requires more than technical instruction; it demands a balance between theory, legal frameworks, and applied practice. For instance, blending authentic tasks such as bills of quantities and real contract documents with theoretical instruction promotes deeper engagement, though explicit scaffolding is still necessary to strengthen students' mastery of estimation theory and legal obligations (Patil, Ayer, McCord, Perry, Wu, London, & Kline, 2025). A recurring challenge is bridging legal knowledge with cost assessment skills, given the need to integrate abstract legal principles with numerical analysis. Recent reforms in engineering curricula have therefore emphasized embedding legal awareness into technical training to align learning with industry practice (Seng Hansen, Saleh, & Apwiddhal, 2025; Yang, 2024). In this regard, contract administration is consistently recognized as a cornerstone of project success, with studies highlighting its effectiveness in reducing disputes and facilitating smoother project delivery (Gündüz & Elsherbeny, 2020; Zhang et al., 2025). Collectively, these insights reinforce the need for pedagogical approaches that move beyond technical competence to cultivate students' ability to integrate contractual, managerial, and technical principles effectively in professional practice.

Outcome-Based Education and CLO/LOD in Engineering

Within the OBE framework, constructive alignment ensures that learning objectives, teaching methods, and assessments are coherently structured to achieve the intended outcomes (Li & Rohayati, 2024). Recent reviews highlight challenges in achieving deep cognitive outcomes unless assessments are carefully designed to demand higher-order thinking (Mahrishi, Ramakrishna, Hosseini, & Abbas, 2025). Malaysian engineering accreditation framework (EAC) requires ongoing monitoring of LO attainment and CQI (EAC, 2024).

Assessment Types and Student Performance Across Learning Domains

Continuous assessment (CA) including quiz, assignment, test, and project has become central to ensuring student engagement and providing formative feedback. Studies have found that CA is a strong predictor of overall coursework performance but less precise for predicting final exam outcomes, which are influenced by exam design, student anxiety, and the cognitive demands of exam items (Nachouki, Mohamed, Mehdi, & Abou Naaj, 2023; Morales, Salmerón, Maldonado, Masegosa, & Rumí, 2022). In higher or tertiary education context, whether during COVID-19 with remote learning or under normal, face-to-face conditions, students tend to achieve high levels of affective and psychomotor outcomes, while cognitive mastery consistently lags. Evidence shows that both online and alternative assessments as well as conventional in-class assessments reveal stronger performance in practical and affective tasks than in theoretical knowledge components (Kabir, Abdullah, Tooheen & Hasan, 2023; Mohd Noor et al., 2020).

This trend is further reinforced by empirical studies in engineering education demonstrating that students perform better in applied, project-based, and experiential tasks (psychomotor and affective domains) than in theoretical or cognitive tasks. For example, field excursions and practical tasks in construction measurement education were found to significantly enhance psychomotor competence, though students still struggled with theory application (Ismail, Che Hasan, Abu Bakar, Md Supie, Sharipudin, & Zainuddin, 2024). Similar patterns are observed across other engineering disciplines, where psychomotor outcomes are more consistent than cognitive results (Cheah et al., 2023; Liew et al., 2023). Collectively, these findings underscore the persistent imbalance between psychomotor/affective learning and cognitive mastery in engineering programmes.

Beyond assessment modes, student achievement is also influenced by instructional strategies, prior learning experiences, and curriculum design. Studies show that experiential and scenario-based tasks substantially improve comprehension of complex technical topics (Tembrevilla, Phillion, & Zeadin, 2024; Zhao, Hou, & Gu, 2022). This alignment is particularly important in courses such as Contracts and Estimation, where technical theory, legal principles, and measurement skills converge. Nonetheless, consistent evidence from Malaysian engineering programmes indicates that cognitive performance, especially in examinations, remains the weakest domain of student achievement in comparison to psychomotor and affective outcomes (Mohd Noor et al., 2020; Sihab, Zanal, Zulhanip, Ismail, & Md Sharif, 2024).

3. RESEARCH METHODOLOGY

Research Design

This study adopted a quantitative, descriptive–analytical design to examine student performance and learning outcome attainment in a Contracts and Estimation course. The analysis combined descriptive statistics, correlation and regression modelling, and OBE attainment measurement to capture both performance patterns and alignment with the institutional benchmarks. Descriptive statistics, such as average learning outcome scores, are commonly used as an initial step to summarise assessment results and identify overall performance trends before undertaking deeper analysis for continuous quality improvement (Mohd Noor, Saim, Alias & Rosli, 2024). Correlation analysis was used to assess the strength of associations between different assessment components, offering insights into how formative tasks relate to summative performance (Li, Yeung, Li & Leung 2021; Jones & Oh, 2024). Multiple regression modelling was then employed to evaluate the predictive power of continuous assessments on final exam scores and overall achievement, consistent with recent approaches to academic performance prediction in engineering education (Ravikumar & Sasikala, 2024; Morales et al., 2022).

CLO and LOD attainment analysis benchmarked student outcomes against the institutional OBE standards. This alignment is strongly recommended in outcome-based curriculum evaluations, both to demonstrate compliance with national accreditation requirements and to guide continuous quality improvement (CQI) processes (EAC, 2024). Collectively, these methods provide a rigorous and multidimensional approach to evaluating student performance, integrating statistical modelling with OBE-driven evaluation metrics.

Course Description, Participants, and Data

The Contracts and Estimation course was a core subject offered in the third year of the undergraduate civil engineering programme. It was designed to introduce students to fundamental principles of construction contract administration and cost estimation techniques. The course content covered key areas such as the fundamentals of contract law (elements of contract formation, methods of discharge, and remedies for breach), procedures for contract administration, and classification of different types of construction contracts. Technical topics included preliminary cost estimation, quantity measurement (take-off) for selected structural components, and build-up of unit rates.

The course was delivered through lectures and tutorials over a 14-week semester and carried a total of 3 credit hours. Three Course Learning Outcomes (CLOs) reflected the cognitive, psychomotor, and affective domains of learning. CLO1 assessed the ability to apply appropriate types of construction contracts and administrative procedures in response to project scenarios, addressing the cognitive domain up to C3 (Application). CLO2 focused on the psychomotor domain up to P3 (Precision), requiring students to perform preliminary cost estimation and quantity take-off. CLO3 emphasized the affective domain up to A2 (Responding to Phenomena), requiring students to demonstrate the significance of proper contract procedures in effective project delivery.

A combination of formative and summative assessments was employed to support learning and evaluate performance. Formative assessment is an intentional, ongoing process in which instructors gather and use evidence of students' understanding to guide teaching and enhance learning outcomes (Baartman & Gulikers, 2025; 3a). In this course, it was embedded through quizzes, a mid-term test, and a group assignment, providing students with timely feedback to adjust their learning strategies. Summative assessment, by contrast, evaluates whether students have achieved the intended learning outcomes and is typically used for grading or certification (Subheesh & Sethy, 2020). The summative components in this course included a group project and a final examination.

The dataset comprised performance records from 53 students enrolled in the course during one semester. Quizzes, a mid-term test, a group assignment, and the final exam primarily assessed the cognitive domain, whereas the group project extended to affective, cognitive, and psychomotor components. Two dependent variables were considered: the final exam score and the total score, representing overall performance. Independent variables comprised the continuous assessment components, namely assignment, quizzes, test, and the three project components. CLO and LOD attainment were mapped according to the institutional OBE standards: CLO1 corresponded to LOD1 (cognitive domain: knowledge & understanding), CLO2 to LOD12 (affective domain: autonomy & responsibility), and CLO3 to LOD15 (psychomotor domain: ethics). Attainment was evaluated through mean scores and the proportion of students achieving or exceeding the institutional benchmark of 55%, providing a holistic assessment of theoretical knowledge, affective engagement, and applied skills.

Data Analysis Procedures

The analysis was conducted in four stages. First, descriptive statistics (mean, standard deviation, and range) were generated to summarize performance across assessment components. Second, correlation analysis was performed to explore relationships among the components and their association with both final exam and total score. Third, multiple linear regression was applied in two models: Model A identified predictors of the final exam, while Model B examined predictors of total performance. Finally, CLO and LOD attainment analysis was carried out by calculating the proportion of students meeting the 55% benchmark and visualizing the results using radar charts. These procedures ensured a comprehensive evaluation of both performance outcomes and their alignment with OBE expectations.

4. DATA ANALYSIS AND FINDINGS

Descriptive Statistics of Assessments

Table 1 summarizes the descriptive statistics of all assessment components. Students performed consistently well in project-based components, while quizzes and tests exhibited greater variability. The final exam showed the widest score distribution, making it the primary differentiator of overall student performance. The average total score (~71%) indicates that most students surpassed the OBE benchmark of 55%.

Table 1: Descriptive Statistics of Assessment Components

Component	Mean	Standard Deviation (SD)	Min	Max
Assignment	3.6	0.7	2	5
Quiz	3.5	1.5	0.5	5
Test	10.5	4.2	0	20
Project – Affective	6.8	1.1	3.5	7.5
Project – Cognitive	4.5	0.8	2	5
Project – Psychomotor	6.9	0.9	4	7.5
Final Exam	35.2	14	0	50
Total Score	71	15	20	95

Figure 1 complements these results by illustrating the distribution of scores across all components. The final examination displayed the broadest spread, reflecting considerable variability in cognitive performance, while project components were tightly clustered, indicating consistent achievement in applied and affective domains. Quizzes revealed moderate variability, whereas assignments were narrowly distributed, suggesting uniform engagement. Despite variation in final exam performance, overall scores clustered around the mean, supported by strong project outcomes.

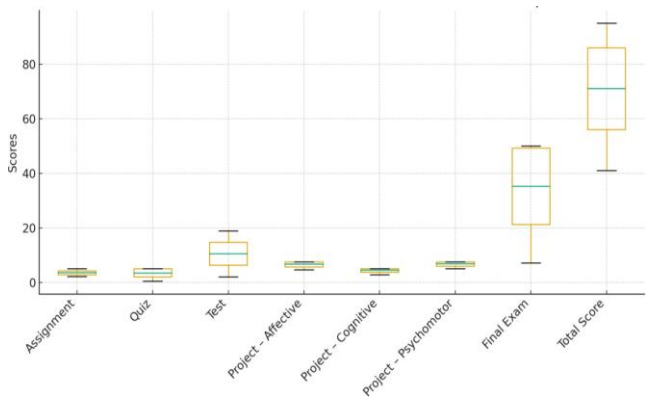

Figure 1. Distribution of student performance across assessment components

While the descriptive statistics provide an overview of how students performed across individual assessment components, they do not explain how these components interact with one another or contribute to overall achievement. To gain deeper insight, the next section examines the relationships among assessment types, focusing on how continuous assessments and project components are linked to both final exam performance and total course outcomes.

Correlation Analysis of Assessment Components

Figure 2 presents the correlation heatmap showing relationships among assessment components and overall course performance. The strongest correlation was observed between the final examination and the total score (r = .97), indicating that performance in the final examination was the most influential determinant of overall achievement. The test component also showed a strong association with both the total score (r = .84) and the final examination (r = .71), reflecting consistency in students' cognitive performance across major summative assessments.

Moderate correlations were found for quizzes (r = .50), project affective (r = .43), and project cognitive (r = .40) with total performance. Assignment scores were strongly correlated with the project affective component (r = .82), suggesting that students who engaged well with coursework also tended to perform effectively in affective tasks. In contrast, assignments (r = .34 with total) and the project psychomotor component (r = .28 with total) showed weaker links to overall performance.

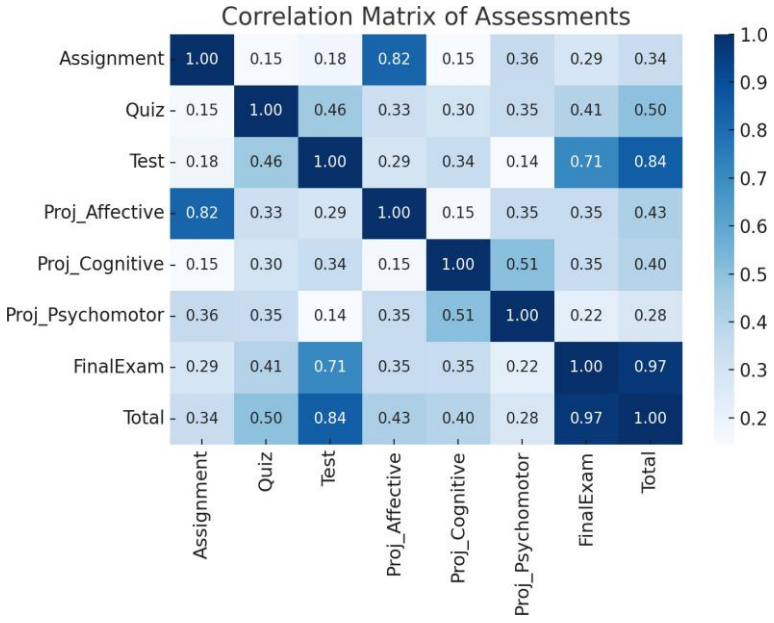

Figure 2. Heatmap of correlations between assessment components and overall performance.

These findings indicate that course outcomes were predominantly driven by cognitive- based assessments, particularly the test and final examination, while continuous assessments and project components played a more moderate role. This imbalance underscores the need to review the weighting of assessment components to achieve a more balanced measurement of cognitive, affective, and psychomotor learning outcomes in line with OBE principles. The dominance of high-stakes examinations echoes prior studies showing that cognitive-based assessments remain central in shaping student outcomes (Nachouki et al., 2023); Morales et al., 2022). However, the moderate correlations between continuous assessments and exam performance suggest a misalignment between formative and summative components, raising questions about whether current assessment design sufficiently reinforces higher-order cognitive skills, an ongoing challenge in OBE implementation globally (Mahrishi et al., 2025).

Regression Analysis

To extend the correlation findings, regression analysis was performed using two models (Table 2). Model A, which predicted final examination performance from continuous assessment components, yielded moderate explanatory power (R^2 = .55), with the test identified as the only significant predictor. Model B, which predicted total course performance, demonstrated near-perfect explanatory power (R^2 = 1.00), where all continuous assessment components together with the final examination contributed significantly. These findings indicate that while the final exam remains the dominant determinant of achievement, continuous assessments provide a more comprehensive measure of student performance under OBE.

Table 2. Summary of Regression Models Predicting Final Examination (Model A) and Total Score (Model B)

Model	**Dependent Variable**	**Key Predictors (Significant)**	**R^2**
Model A	Final Exam	Test (β = 1.523, $p < .001$)	0.55
Model B	Total Score	Assignment, Quiz, Test, Projects (affective, cognitive, psychomotor), Final Exam (all $p < .001$)	1

Note. Only statistically significant predictors are reported. R^2 = coefficient of determination.

These findings highlight both strengths and weaknesses in the current assessment structure. While continuous assessments effectively capture overall performance and align well with OBE expectations, their limited predictive power for final exam outcomes points to an imbalance in how cognitive learning is measured. The strong influence of the final exam suggests that high-stakes summative testing continues to dominate achievement, potentially overshadowing other forms of psychomotor and affective learning where students perform consistently well. This raises important questions for assessment design and CQI, particularly regarding how to better integrate cognitively demanding tasks within continuous assessment to ensure more balanced attainment across domains.

These findings are also consistent with international evidence showing that continuous assessments provide reliable indicators of student engagement and learning progress but are less effective at capturing the deep cognitive abilities examined in high-stakes testing (Paloposki, Virtanen, & Clavert, 2025). From an OBE perspective, this suggests that continuous assessments can serve as an early-warning system for identifying at-risk students, enabling timely intervention and support before final examinations (Skittou, Merrouchi, & Gadi, 2024).

In sum, while continuous assessments offer a reliable picture of overall student performance, the dominance of the final examination underscores the need to recalibrate assessment design, an issue further illuminated by the analysis of CLO and LOD attainment in the following section.

CLO and LOD Attainment

As shown in Table 3, attainment exceeded the institutional benchmark of 55% across all domains, with approximately 65% for CLO1/LOD1 (cognitive), 95% for CLO2/LOD12 (affective), and 90% for CLO3/LOD15 (psychomotor). These results indicate consistently strong performance in affective and psychomotor outcomes, but comparatively weaker attainment in the cognitive domain.

Table 3. CLO and LOD Attainment Against 55% Benchmark

CLO	Mapped LOD (Domain)	Attainment (%)	Benchmark (%)	Interpretation
CLO1	LOD1 (Cognitive)	65	55	Moderate attainment, below affective/psychomotor
CLO2	LOD12 (Affective)	95	55	Strong attainment, well above benchmark
CLO3	LOD15 (Psychomotor)	90	55	Strong attainment, well above benchmark

Note. Attainment was evaluated against the institutional benchmark of 55%.

Figure 3 complements these results by illustrating the distribution of attainment relative to the benchmark. The radar chart highlights that while all domains exceeded the threshold, cognitive attainment lagged applied and affective domains. This imbalance suggests that students are more proficient in applied and affective tasks, whereas cognitive learning outcomes require additional scaffolding to achieve the same level of mastery.

These findings align with Malaysian engineering education literature, which has repeatedly observed stronger performance in applied and affective domains relative to theoretical mastery (Ismail et al., 2024; EAC, 2024). While overall attainment meets institutional expectations, the relative weakness in the cognitive domain highlights the need to strengthen scaffolding for theoretical and problem-solving skills. This underscores the importance of constructive alignment, ensuring that assessments are explicitly mapped to intended CLOs and LODs across all domains (Biggs et al., 2022).

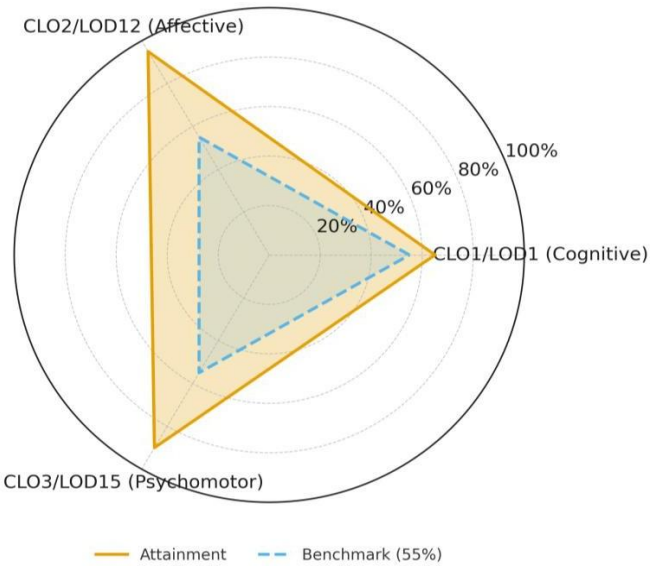

Figure 3. CLO and LOD Attainment vs Benchmark

5. CONCLUSION

This study assessed civil engineering students' performance in a Contracts and Estimation course under Malaysia's Outcome-Based Education (OBE) framework. The findings show strong attainment in affective and psychomotor domains but weaker cognitive mastery, particularly in final examinations. While continuous assessments strongly predicted overall performance, their explanatory power for exam outcomes was only moderate, reflecting the continued dominance of high-stakes testing.

The results highlight the need for more cognitively demanding tasks within continuous assessment, such as case-based scenarios and integrated estimation exercises, to strengthen higher-order thinking and align with final exam expectations. At the curriculum level, explicit mapping across cognitive, affective, and psychomotor domains is essential to achieve balanced OBE outcomes and ensure accreditation compliance.

Beyond practice, this study contributes to engineering education literature by linking CLO/LOD attainment with predictive modelling, offering a framework for evaluating assessment-outcome relationships. Future research should expand to larger and more diverse cohorts, employ longitudinal and mixed-method approaches, and explore how teaching strategies and student factors interact with assessment design. Collectively, these efforts can support continuous quality improvement (CQI) and ensure graduates are both industry-ready and equipped with advanced analytical reasoning skills.

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