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EVALUATION OF ENGINEERING STUDENTS' LEARNING OUTCOMES: CREATING A CULTURE OF CONTINUOUS QUALITY IMPROVEMENT

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Abstract:

The Engineering Accreditation Council (EAC) requires the implementation of an outcome-based education (OBE) approach in all engineering programs in Malaysia, emphasizing the evaluation of course learning outcomes (CLOs). The student learning outcome for Solid Waste Management has been assessed as it is one of the courses taught in Civil Engineering Programme. In Malaysia, solid waste management is an important part of engineering education because of its direct impact on environmental sustainability and public health. The course covers the elements involved in solid waste management, implementing and evaluating efficient, sustainable and cost-effective waste management systems. This study evaluates the attainment of specified CLOs for a solid waste management course; eligible to be taken by all civil engineering students in a private university in Malaysia. The three main CLOs were evaluated based on curriculum alignment with Program Outcomes (PO) and Course Learning Outcomes (CLO) as documented in the EAC Self-Assessment Report. Attainment of these outcomes was measured by student performance on formative and summative assessments, particularly CLO1, CLO2 and CLO2. Semester 32334 results showed the highest overall achievement in CLO, while CLO1 showed the lowest achievement, ranging from 39.4% to 55.8%. Other CLOs achieved significantly higher rates, ranging from 72 percent to 95.9 percent. These findings highlight the need to refine targeted instructional strategies to improve learning outcomes in future offerings of the course.

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Introduction

In Malaysia, the Engineering Accreditation Council (EAC) is pivotal in ensuring the quality of engineering education through Outcome-Based Education (OBE) initiatives. The EAC focuses on assessing and evaluating Program Outcomes (POs) within the engineering curriculum to drive continuous quality improvement in engineering programs (Liew & Kiew, 2022; Liew et al., 2021). The implementation of OBE in teaching and learning has become a standard practice in Malaysian higher education institutions to meet the EAC's requirements. Additionally, the EAC mandates that engineering programs include courses on engineering ethics education to foster ethical awareness among engineering undergraduates.

One of the key strategies to meet EAC standards is the integration of active learning methodologies in engineering courses. Active learning has been proven to enhance students' problem-solving skills, aiding in achieving course outcomes and overall program outcomes (Hadibarata & Rubiyatno, 2019). Moreover, the EAC underscores the significance of industrial training to expose students to professional engineering practices, aligning to prepare graduates for the industry (Saim et al., 2021). The EAC's accreditation standards also emphasize the assessment of POs to facilitate continuous quality improvement in engineering education (Liew et al., 2021).

Continuous quality improvement is essential in Outcome-Based Education (OBE) as it aligns with the core principles of OBE, which emphasize student-centeredness, output orientation, and continuous improvement. In the context of OBE, continuous quality improvement ensures that educational programs are constantly evaluated, refined, and enhanced to meet the desired learning outcomes and objectives. By implementing a culture of continuous improvement, educational institutions can adapt to the evolving needs of students, enhance the quality of education provided, and cultivate innovative and competent graduates.

Ren (2024) delves into the application of Total Quality Management (TQM) in higher education, emphasizing the importance of continuous improvement in educational institutions. It highlights how TQM principles, including continuous improvement and data-driven decision-making, can be instrumental in enhancing curriculum design, teaching methods, and student assessments. It is significant to monitor and improve the assessment process based on student performance data and feedback to ensure the relevance and effectiveness of measuring learning outcomes.

By continuously monitoring and analyzing the learning outcome of students, promptly identifying and addressing issues, and engaging in ongoing optimization efforts, the quality and effectiveness of education can be significantly enhanced. This approach aligns with the importance of continuous quality improvement in monitoring course learning outcomes, ensuring that educational decisions are relevant and effective through data-driven techniques.

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The EAC's emphasis on OBE, active learning, ethics education, and industrial training highlights its dedication to enhancing the quality of engineering education in Malaysia. By establishing rigorous standards and promoting continuous quality improvement, the EAC plays a crucial role in shaping the future of engineering education in the country.

Methodology

A qualitative approach is adopted through a document review based on data extracted from the Outcome-Based Education (OBE) system known as MyOutcome. This approach involves systematically examining and interpreting various documents to gain a deep understanding of the learning outcomes and their trends. Specifically, a longitudinal method is employed to collect data from the same MyOutcome analysis for the solid waste management course over five semesters: November 2020 (32034), April 2021 (12134), April 2022 (12234), November 2022 (32234), and November 2023 (32334). The longitudinal method is a research approach that involves collecting data from the same subjects repeatedly over a period to observe changes, trends, or developments. Unlike cross-sectional studies, which capture a snapshot of data at a single point in time, longitudinal studies provide insights into how variables evolve and allow researchers to examine relationships, patterns, and causal effects over time (Chen & Culpepper, 2020).

By utilizing this method, researchers can identify trends in student performance, track the effectiveness of teaching methods, and observe the impact of curriculum changes. This approach is particularly valuable in educational research as it reveals how students' learning outcomes develop over multiple semesters, offering a comprehensive view of the course's long-term effectiveness. For instance, tracking improvements in Course Learning Outcome 1 (CO1) across the specified semesters allows for a detailed analysis of whether instructional strategies and curricular adjustments have positively influenced student understanding and mastery of the subject matter. Moreover, it helps in identifying any consistent patterns or irregularities that may inform future educational practices and policy decisions.

The achievement of course outcomes is facilitated through our proprietary software, MyOutcome, meticulously crafted in-house to streamline the educational process. As depicted in Figure 1, MyOutcome serves as the cornerstone of our academic framework, providing a robust platform for tracking and evaluating student progress. This software is designed to integrate seamlessly with the curriculum, allowing for real-time monitoring and assessment of Course Learning Outcomes (CLOs).

Through its intuitive interface, MyOutcome enables educators to easily input and analyze data related to student performance. The software's sophisticated algorithms process this data to generate detailed reports and visualizations, highlighting trends and pinpointing areas where students excel or struggle. This comprehensive assessment capability allows educators to identify gaps in understanding and adjust their teaching strategies accordingly.

Moreover, MyOutcome empowers educators to provide targeted support and feedback tailored to each student's learning journey. By offering insights into individual and group performance, the software ensures that interventions are timely and effective, addressing specific needs and promoting continuous improvement. For instance, if a particular cohort shows a consistent struggle with CO1, educators can delve into the MyOutcome data to understand the root causes

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and implement corrective measures, such as supplementary materials or modified teaching approaches.

Additionally, MyOutcome supports the longitudinal analysis of student performance across multiple semesters. This functionality is crucial for understanding how learning outcomes evolve over time, helping educators and administrators to refine curricula and instructional methods. By maintaining a historical record of student achievements and challenges, MyOutcome facilitates a data-driven approach to education, promoting evidence-based decision-making.

In summary, MyOutcome is a powerful tool that enhances the educational process by providing a detailed, real-time view of student progress and facilitating the targeted support necessary for achieving course outcomes. Its user-friendly design and advanced analytical capabilities make it an indispensable asset for educators committed to fostering academic excellence.

Results

CLO Attainment Results

(A CLO is considered attained if 50 % (or more) of the students obtain 50 % or more of their assessment marks related to the CLO)
For cohort, the ave. score for all students must be 50 % or more.)

	PREVIOUS SEMESTER :			32234	CURRENT SEMESTER :				32334
	CLO Statement	Results		Action Plan (your promises from last semester)	Implementation (what you actually did this semester)	CLO Statement	Results		Comments and Action Plan (your promises this semester)
		%ATT	AVER.				%ATT	AVER.	
CLO1	Formulate and solve engineering problems and process related to solid waste management system	NO	30	39.3631	To emphasize on certain topics and to give more and different exercises to make sure students are familiar with the blooms and pattern of questions.	ALL ACTIONS TAKEN LAST SEMESTER HAS PROVEN TO ATTAIN ALL CLO WELL. THUS FOR THE UPCOMING SEMESTER, SAME ATTENTION WILL BE GIVEN TO DELIVER THE COURSE INFORMATION, BLOOM TAXONOMY UNDERSTANDING AND EXPOSE STUDENTS TO JOURNALS. AS OTHER PREVIOUS SEMESTER, WILL ADVISE THEM TO STUDY SMART AND MANAGE THEIR TIME EFFECTIVELY FOR ALL COURSES. ADDITIONAL PROJECT WAS GIVEN TO STUDENTS TO ASSESS ON THE GROUP WORK.	Formulate and solve engineering problems and process related to solid waste management system	YES	71.4	55.8	ALL CLOs were attained. Focus on improving the CLO attainment for the following semester.
CLO 2	Evaluate the design system and the concept of a closure, restoration and rehabilitation system for MSW and Scheduled waste	YES	90	80.8333		Evaluate the design system and the concept of a closure, restoration and rehabilitation system for MSW and Scheduled waste	YES	100.0	72.0	
CLO 3	Demonstrate the ability to interact with others as team member/leader	YES	100	78.75		Demonstrate the ability to interact with others as team member/leader	YES	100.0	89.0	
CLO 4										
CLO 5										

Figure 1:

Figure 1 shows the results of course learning outcomes (CLOs) for Solid Waste Management course across two consecutive semesters, November 2022 and November 2023, highlights a notable improvement in Course Learning Outcome 1 (CO1). Specifically, the average score for CO1 increased from 39.3% in November 2022 to 55.8% in November 2023, reflecting a significant enhancement of 50 percentage points. This improvement can be attributed to several factors considering the proposed action plan stated enhanced teaching methods, such as interactive lectures emphasizing on few topics. The availability of extra resources, provided students with a more comprehensive understanding of the subject matter. Improved student support systems, such as tutoring and study groups, also contributed to this positive outcome by offering additional avenues for student assistance and learning. The shift in assessment methods from traditional exams to continuous assessments, such as quizzes, projects, and presentations, allowed for a more accurate and ongoing measurement of student understanding and progress. Overall, the improvement in CO1 suggests that students have gained a better grasp of foundational concepts in solid waste management, which can positively impact their

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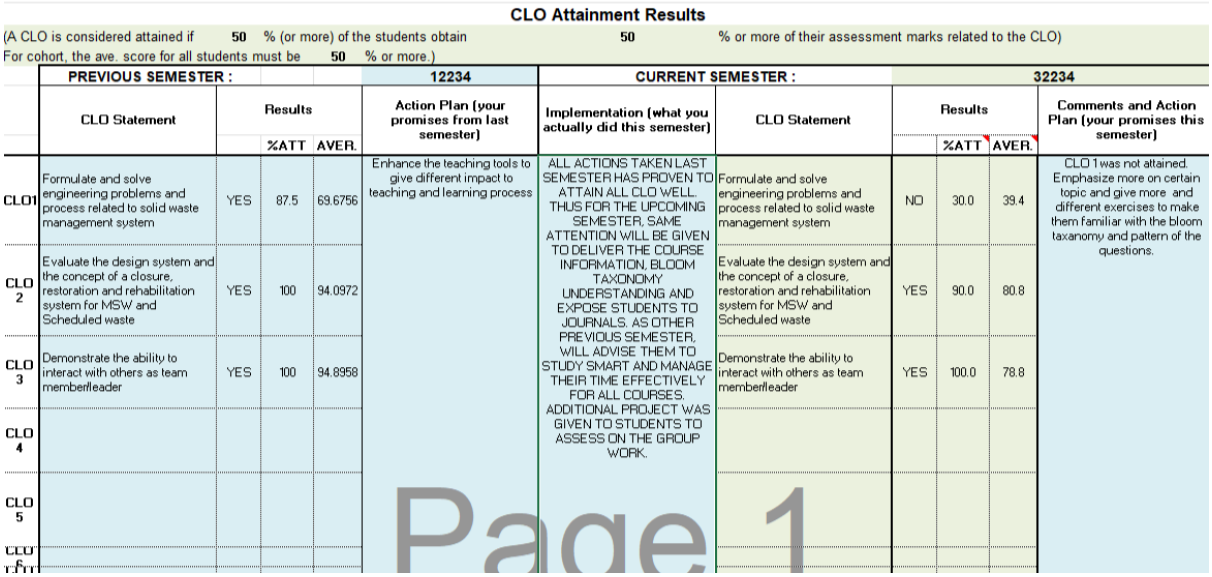
performance in advanced topics and practical applications. This progress reflects well on the teaching methods and curriculum design, indicating that any implemented changes were effective. The insights gained from this data can inform future course planning, encouraging the continuation of successful strategies and further refinements to address any remaining challenges in other CLOs. In order to improve course outcomes, the lecturers can consider implementing mandatory participation requirements in online discussion forums, as suggested by (Du et al., 2022). This strategy can enhance learner engagement, encourage active participation, and ultimately lead to improved learning performance among students.



CLO Attainment Results

(A CLO is considered attained if 50 % (or more) of the students obtain 50 % or more of their assessment marks related to the CLO)
For cohort, the ave. score for all students must be 50 % or more.)

	PREVIOUS SEMESTER :				12234	CURRENT SEMESTER :					32234
	CLO Statement	Results			Action Plan (your promises from last semester)	Implementation (what you actually did this semester)	CLO Statement	Results			Comments and Action Plan (your promises this semester)
			%ATT	AVER.					%ATT	AVER.	
CLO1	Formulate and solve engineering problems and process related to solid waste management system	YES	87.5	69.6756	Enhance the teaching tools to give different impact to teaching and learning process	ALL ACTIONS TAKEN LAST SEMESTER HAS PROVEN TO ATTAIN ALL CLO WELL. THUS FOR THE UPCOMING SEMESTER, SAME ATTENTION WILL BE GIVEN TO DELIVER THE COURSE INFORMATION, BLOOM TAXONOMY UNDERSTANDING AND EXPOSE STUDENTS TO JOURNALS. AS OTHER PREVIOUS SEMESTER, WILL ADVISE THEM TO STUDY SMART AND MANAGE THEIR TIME EFFECTIVELY FOR ALL COURSES. ADDITIONAL PROJECT WAS GIVEN TO STUDENTS TO ASSESS ON THE GROUP WORK.	Formulate and solve engineering problems and process related to solid waste management system	NO	30.0	39.4	CLO 1 was not attained. Emphasize more on certain topic and give more and different exercises to make them familiar with the bloom taxanomy and pattern of the questions.
CLO 2	Evaluate the design system and the concept of a closure, restoration and rehabilitation system for MSW and Scheduled waste	YES	100	94.0972			Evaluate the design system and the concept of a closure, restoration and rehabilitation system for MSW and Scheduled waste	YES	90.0	80.8	
CLO 3	Demonstrate the ability to interact with others as team memberfleader	YES	100	94.8958			Demonstrate the ability to interact with others as team memberfleader	YES	100.0	78.8	
CLO 4											
CLO 5											
CLO 6											

Figure 2

The same teaching methods and course design can yield different results across various cohorts of students due to several factors unique to each group. Differences in prior knowledge and preparedness mean that some students may have a stronger foundational understanding, allowing them to grasp advanced topics more quickly, while others may struggle. Additionally, each cohort may have diverse learning styles, with some students responding better to visual or hands-on methods, and others preferring auditory or reading-based approaches. Figure 2 shows that even action taken accordingly, the results decline. Motivation and engagement levels also play a significant role; a highly motivated group is likely to engage more deeply with the material, leading to better outcomes, whereas a less motivated cohort might not achieve the same level of success. External circumstances, such as socioeconomic background and personal challenges, can further impact performance, as can the social dynamics within the group. Variations in assessment methods and the timing and utilization of feedback can also influence results, as different cohorts may respond differently to exams, projects, or presentations. Additionally, the rapport between the lecturer and the students, and the lecturer's ability to adapt their teaching style to meet the needs of each cohort, can significantly affect learning outcomes. Therefore, while the teaching methods remain consistent, the diverse characteristics and circumstances of each student cohort can lead to different academic results.

Based on the performance of each cohort, it is essential to adapt and modify improvement plans accordingly. As highlighted by (Sniehotta, 2009), progress in intentional behavior change can be achieved by disentangling planning constructs, studying their effects on behavior, and

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integrating planning processes within learning and self-regulation theory. By continuously evaluating the effectiveness of improvement plans and considering evidence-based behavior change techniques, educators can tailor interventions to meet the specific needs and challenges of each cohort. This adaptive approach ensures that strategies remain relevant and impactful, ultimately leading to enhanced course outcomes in engineering education. It is evident that the effectiveness of action plans in improving performance is contingent upon the specificity and relevance of the plans created by students. As lecturers and educators emphasize the importance of action plan in education, the study highlights that the cohort of students may not always suitable to the specific action plans that directly address the weakness from the previous semester.

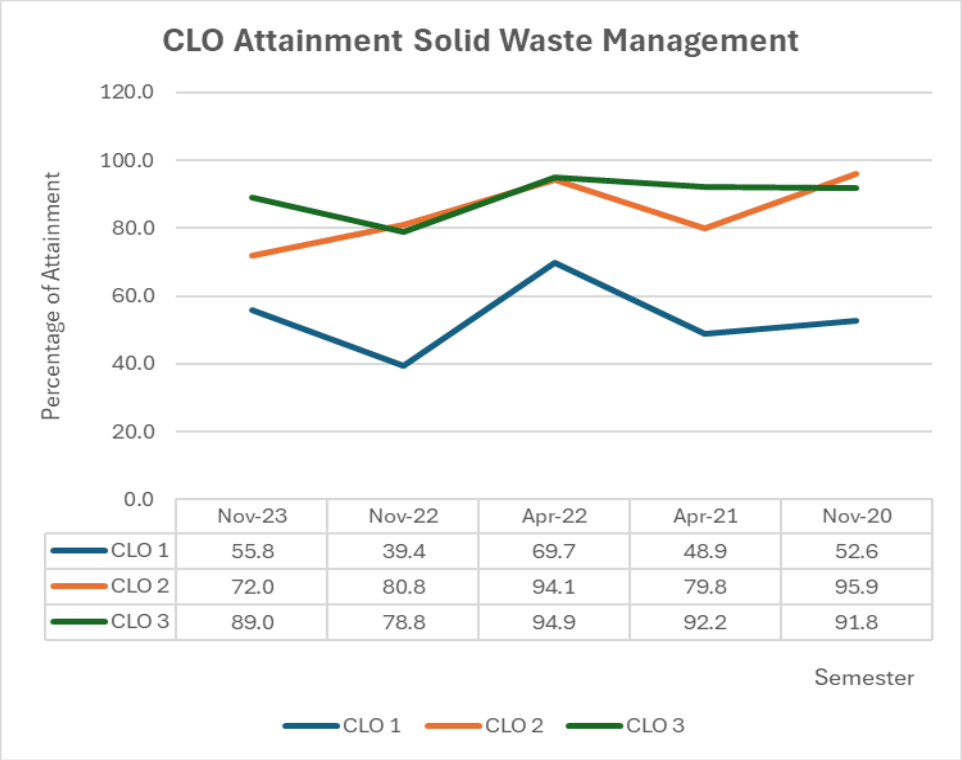

Figure 3

Figure 3 illustrates the fluctuating trend of course learning outcomes despite the implementation of various action plans. This variability can be attributed to several factors, particularly the differences in the cohorts of students enrolled each semester. Each cohort of students brings a unique set of backgrounds, skills, and learning abilities. Some cohorts may have stronger foundational knowledge or better-prepared students, leading to higher learning outcomes. Conversely, other cohorts might struggle more due to gaps in their prior knowledge or varying levels of preparedness, resulting in lower outcomes despite similar action plans.

The effectiveness of action plans might also vary between cohorts. These plans can be highly effective for one group of students but less effective for another, due to differences in learning styles, motivations, and engagement levels. For example, a project-based approach might resonate well with one cohort but might not engage another cohort as effectively. Additionally, the effectiveness of teaching methods can vary depending on the lecturers. Different teaching styles, levels of experience, and personal engagement with students can impact the overall

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effectiveness of the course delivery. The lecturer's ability to adapt to the needs of each cohort can also play a significant role.

External factors such as changes in curriculum, availability of resources, and institutional support can significantly impact learning outcomes in students (Kitsantas et al., 2011). These factors play a crucial role in shaping the educational experience and influencing the effectiveness of teaching and learning processes. One of the key external factors that can influence learning outcomes is the availability of resources (Cassidy, 2015). Adequate resources, such as textbooks, technology, and learning materials, are essential for creating a conducive learning environment and supporting student learning. Lack of resources can hinder students' ability to access information, engage in meaningful learning activities, and achieve desired learning outcomes.

Changes in curriculum can also have a significant impact on learning outcomes (Lee et al. 2010). Curriculum revisions, updates, or modifications can affect the content, structure, and delivery of educational programs, influencing students' learning experiences and outcomes. A well-designed and relevant curriculum can enhance student engagement, motivation, and achievement, while an outdated or ineffective curriculum may impede learning and hinder academic progress.

Institutional support is another critical external factor that can influence learning outcomes. Support from educational institutions, administrators, teachers, and staff members is essential for creating a supportive and nurturing learning environment. Institutional support can include access to academic support services, counseling, mentoring, and extracurricular activities that enhance students' overall learning experience and contribute to their academic success. Additionally, institutional policies, practices, and resources can impact students' ability to achieve desired learning outcomes and reach their full potential. (Soria et al., 2013)

To address the variability in learning outcomes, it is essential to adopt a more flexible and adaptive approach. Regular assessment and feedback mechanisms should be implemented to identify the specific needs and challenges of each cohort early in the semester, allowing for timely adjustments to teaching strategies and support. Differentiated instruction techniques can cater to diverse learning styles and abilities within each cohort by varying the types of projects, assessments, and teaching methods used. Investing in professional development for lecturers can equip them with the skills and strategies needed to effectively engage and support diverse student groups. Enhancing student support services such as tutoring, mentoring, and counseling can help students overcome individual challenges and bridge gaps in knowledge and skills more effectively (Kivlighan et al. 2021). Additionally, maintaining strong ties with the industry ensures that the curriculum remains relevant and aligned with current demands. By understanding and addressing the underlying causes of fluctuations in course learning outcomes, institutions can better tailor their approaches to meet the needs of each cohort, thereby enhancing the overall effectiveness of engineering education.

Conclusion

Continuous quality improvement is paramount in assessing course learning outcomes, particularly in the context of Outcome-Based Education (OBE). The challenges faced by educators in evaluating learning outcomes necessitate the adoption of sophisticated evaluation models and analytical tools to enhance the quality of education. By cultivating a culture of

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continuous improvement and utilizing culminating assessment models and integrated analytical tools, educators can effectively monitor and enhance student learning outcomes, ensuring alignment with accreditation requirements and promoting the development of graduates' intellectual skills and capabilities Liew et al. (2021).

In conclusion, the integration of continuous quality improvement practices in assessing course learning outcomes not only facilitates the evaluation of student performance but also drives educational institutions towards excellence. By embracing a culture of ongoing enhancement, educators can address challenges, refine assessment processes, and implement data-driven strategies to optimize learning outcomes. Through the adoption of best practices in continuous quality improvement, institutions can meet accreditation standards, enhance educational quality, and ultimately empower students to achieve their full potential. Continuous quality improvement serves as a cornerstone in the realm of education, ensuring that learning outcomes are effectively monitored, evaluated, and improved to meet the evolving needs of students and the demands of the educational landscape.

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