Advances in Consumer Research
https://acr-journal.com/

Volume-2 | Issue-5 | Oct 2025

Original Research Article

Closing the Loop on CLOs: Evidence-Based Measurement and Pedagogical Enhancements in Technology Management

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Received: 25/08/2025
Revised: 01/09/2025
Accepted: 15/09/2025
Published: 31/10/2025

Abstract— This study evaluates CLO attainment in a Technology Management undergraduate course in Malaysia using a mixed-methods approach. Quantitative analysis from the institutional OBE analytics system (OBEsys) indicates satisfactory achievement in foundational knowledge (CLO1: 78%) and communication skills (CLO3: 81%), but moderate attainment in analytical problem-solving (CLO2: 72%). Complementary student feedback surveys reveal gaps in engagement, a demand for interactive learning, and the importance of formative feedback. Together, these findings inform a four-pillar improvement framework: (i) authentic assessment through project-based learning, (ii) formative feedback cycles supported by transparent rubrics, (iii) targeted scaffolding for analytical tasks, and (iv) analytics-enabled monitoring for continuous improvement. The contribution of this study lies in closing the loop between CLO measurement and actionable pedagogical enhancements. It highlights strategies to strengthen alignment with Malaysia Qualifications Agency (MQA) standards and offers transferable design principles to support graduate employability and future-ready skills in interdisciplinary contexts.

Keywords: Course Learning outcomes (CLO), Outcome based Education (OBE), Assessment

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INTRODUCTION

Outcome-Based Education (OBE) has been widely adopted in higher education systems worldwide as a means of ensuring that teaching, learning, and assessment are aligned with desired graduate attributes and employability needs [1]. In Malaysia, the implementation of OBE is strongly guided by the Malaysian Qualifications Agency (MQA), which emphasizes constructive alignment between Programme Learning Outcomes (PLOs), Course Learning Outcomes (CLOs), delivery strategies, and assessment methods [2]. CLOs, in particular, provide a critical benchmark for evaluating student learning achievement and serve as the basis for curriculum design, accreditation processes, and quality assurance mechanisms [3].

Despite its structured framework, the measurement of CLOs presents significant challenges, particularly within interdisciplinary programmes such as in Technology Management program. These programmes require balancing multiple domains of learning—including cognitive, practical, and affective skills—in ways that capture both disciplinary knowledge and integrative problem-solving abilities [4]. Traditional assessment methods may not fully reflect these multidimensional outcomes, raising questions about the validity, reliability, and comprehensiveness of CLO attainment measures [5]. Moreover, given the increasing demand for graduates who can navigate technological complexity while demonstrating leadership, communication, and teamwork skills, assessment practices must evolve beyond content mastery to include holistic competencies [6].

Recent studies have highlighted the importance of integrating multiple sources of evidence— such as student feedback, rubric-based evaluations, and institutional analytics—to better capture CLO attainment and inform continuous quality improvement (CQI) processes [7]. In particular, the triangulation of quantitative performance

data with qualitative student perspectives has been shown to provide richer insights into learning effectiveness, enabling educators to identify strengths and gaps that might otherwise remain hidden [8]. Such approaches are increasingly recognized as essential for closing the loop in quality assurance, where assessment outcomes are systematically used to inform curriculum design, pedagogical innovation, and institutional policy [9].

In this paper, we evaluate the attainment of CLOs in a Technology Management course by employing a triangulated approach that combines institutional analytics with student feedback. The study has three main objectives: (i) to identify areas of strength and weakness in CLO achievement, (ii) to explore student perceptions of their learning experiences, and (iii) to propose actionable recommendations for enhancing teaching and assessment practices. By doing so, the paper contributes to strengthening assurance of learning, advancing the discourse on CLO measurement in interdisciplinary contexts, and offering practical insights for continuous quality improvement in higher education.

LITERATURE REVIEW

Outcome-Based Education (OBE) and Course Learning Outcomes (CLOs)

Outcome-Based Education (OBE) has been recognized internationally as a learner-centered approach that emphasizes what students are expected to achieve at the end of a learning experience, rather than what instructors intend to teach [1]. By shifting the focus from input- based curricula to outcome-driven standards, OBE ensures that higher education institutions align teaching strategies, assessment practices, and learning activities with clearly defined learning outcomes. This paradigm has been particularly influential in professional and technical education, where transparency, accountability, and assurance of graduate employability are central to policy and practice.

In Malaysia, the Malaysian Qualifications Agency (MQA) has embedded OBE principles within the Malaysian Qualifications Framework (MQF), requiring higher education institutions to demonstrate constructive alignment between Programme Learning Outcomes (PLOs), Course Learning Outcomes (CLOs), and graduate attributes [2]. CLOs are essential benchmarks that articulate the specific knowledge, skills, and attitudes students are expected to acquire by the end of a course. They serve as a basis for accreditation, curriculum design, assessment methods, and assurance of learning processes [10]. I addition, CLOs play a critical role in ensuring transparency and consistency in teaching and learning, enabling both internal and external stakeholders to evaluate educational effectiveness.

Nevertheless, critics have cautioned that CLO-driven education can sometimes risk narrowing the focus of learning to measurable indicators, potentially neglecting broader intellectual development [11]. While CLOs provide clarity and structure, their successful implementation requires robust and meaningful assessment mechanisms to ensure that they do not become mere compliance exercises but rather reflect holistic student learning.

Challenges of CLO Assessment in Interdisciplinary Contexts

Although CLO measurement has been widely implemented, assessing student achievement in interdisciplinary programmes such as Technology Management presents distinctive challenges. Unlike single-discipline courses that focus primarily on technical or cognitive domains, Technology Management integrates diverse fields including engineering, business, information technology, and management. This complexity requires assessment strategies that capture both disciplinary knowledge and interdisciplinary problem-solving competencies [12].

One of the major challenges lies in balancing the measurement of cognitive knowledge with practical and soft skills such as teamwork, leadership, and communication [13]. For example, while quizzes and examinations can effectively measure cognitive knowledge, they may be insufficient in capturing the dimensions of interpersonal collaboration or innovative problem-solving. In this sense, CLO measurement often struggles with validity, as assessments may fail to accurately represent the breadth of learning outcomes intended for students [14].

Another issue concerns reliability, particularly when assessing affective domain. Soft skills are often evaluated through subjective judgment using rubrics, reflective journals, or peer assessment, which can vary significantly depending on the evaluator's interpretation [15]. This raises concerns regarding consistency and fairness across different cohorts and evaluators. Moreover, interdisciplinary programmes demand adaptability, creativity, and critical thinking- competencies that are not always easy to quantify in traditional assessment systems [16].

These challenges highlight the need for more comprehensive approaches that go beyond traditional summative assessments to include multiple sources of evidence that better reflect the holistic nature of interdisciplinary learning.

Assessment Approaches and Triangulation of Evidence

Assessment practices in OBE contexts have evolved significantly, ranging from traditional written examinations to more performance-based evaluations. Conventional methods such as quizzes, assignments, and examinations remain common tools for measuring CLO attainment, particularly in assessing cognitive skills [17]. However, these methods are limited in their ability to evaluate higher-order skills such as problem-solving,

creativity, or teamwork. To address these gaps, many educators have turned to alternative approaches such as rubric-based evaluations, problem-based learning, and peer assessment [18]. Rubrics, for instance, provide structured criteria for assessing complex skills, enhancing both transparency and consistency in evaluation. Similarly, project-based assessments encourage students to integrate knowledge from multiple domains while demonstrating practical and collaborative competencies.

In addition to direct assessment, institutional analytics (OBEsys) have become an increasingly important tool for measuring CLO attainment. By mapping student performance data against specific CLOs, universities can identify patterns of achievement and areas that require improvement [19]. Such data-driven approaches offer valuable insights into curriculum effectiveness and inform evidence-based decision-making. Another critical dimension of CLO assessment is student feedback. While performance data reflects measurable attainment, student perspectives reveal perceptions of learning effectiveness, teaching practices, and assessment fairness [9]. Student feedback provides contextual understanding of how learning outcomes are experienced, highlighting hidden gaps that may not be captured through quantitative measures alone.

For these reasons, scholars increasingly advocate for triangulation in CLO assessment — the integration of multiple data sources such as institutional analytics, rubric-based evaluations, and student feedback [11]. Triangulated evidence not only improves the validity and reliability of outcome measurement but also offers a richer, multidimensional understanding of student learning.

Continuous Quality Improvement (CQI) and Closing the Loop

Central to the OBE framework is the principle of Continuous Quality Improvement (CQI), where assessment outcomes are systematically analyzed and fed back into curriculum and teaching improvements [20]. The concept of "closing the loop" emphasizes the importance of using evidence from CLO measurement not merely as an accountability mechanism but as a tool for pedagogical innovation and quality assurance [9]. CQI practices in higher education often include revising course content, updating teaching methodologies, introducing new assessment tools, and providing targeted support to students based on attainment results. In Malaysia, CQI has become a mandatory component of accreditation processes, where higher education institutions must demonstrate how they use CLO data to enhance curriculum effectiveness and student learning [21].

Internationally, CQI has been widely practiced in engineering, medical, and business education, with evidence showing its effectiveness in enhancing graduate competencies and meeting industry needs [22]. However, while the literature provides strong support for CQI as a mechanism for academic quality assurance, there remains limited research focusing specifically on its implementation within interdisciplinary programmes such as Technology Management.

In a nutshell, while traditional methods provide partial insights, triangulated approaches that integrate institutional analytics, rubric-based assessments, and student feedback offer a more holistic picture of student achievement. Moreover, embedding these assessments within a CQI framework ensures that learning outcomes directly inform pedagogical improvements and accreditation processes. Despite this growing body of research, empirical studies focusing specifically on CLO measurement and CQI in Technology Management remain scarce, presenting a gap that this study seeks to address.

METHODOLOGY

Sample and Context

The study involved 119 undergraduate students enrolled in a core Technology Management course at a Malaysian public university. The course was designed in accordance with the Malaysian Qualifications Framework (MQF) and aligned with Outcome-Based Education (OBE) principles. Its CLOs covered multiple learning domains, including cognitive knowledge, analytical and problem-solving skills, and affective competencies such as communication skills.

Data Collection

Two main types of data were collected to assess CLO achievement:

Quantitative Data: Student performance records were retrieved from the university's OBE system (OBEsys), which tracks CLO attainment across various assessments. These assessments included quizzes, midterm and final examinations, group assignments, class participation, and oral presentations. Each assessment was mapped to one or more CLOs to ensure constructive alignment between assessment methods and intended learning outcomes.

Qualitative Data: Student perceptions were gathered through structured feedback surveys. The survey instrument employed a 5-point Likert scale to measure indicators such as CLO clarity, relevance, and perceived effectiveness, supplemented by open-ended questions that invited students to provide reflective comments on their learning experiences.

Data Analysis

Quantitative data were analyzed using descriptive statistics (means, percentages, and attainment levels) to identify patterns of CLO achievement across the three learning domains. Attainment benchmarks were set in accordance with faculty guidelines (e.g., CLO achievement target ≥ 55% of students attaining ≥ 55% marks). Qualitative data were analyzed through thematic

analysis, which involved coding student comments, identifying recurring themes, and categorizing insights related to course design, teaching effectiveness, and assessment practices. This approach provided deeper understanding of the contextual factors influencing CLO achievement.

Triangulation and Validity

The integration of quantitative performance data and qualitative student feedback enabled methodological triangulation, strengthening the validity and reliability of the findings [23]. Quantitative results provided objective measures of attainment, while qualitative insights contextualized these findings by highlighting student perspectives and experiences. Together, these complementary data sources offered a more holistic evaluation of CLO achievement and informed actionable recommendations for continuous quality improvement.

RESULTS AND DISCUSSION

CLO Attainment

The quantitative analysis revealed varying levels of achievement across the three Course Learning Outcomes (CLOs). CLO1 (Knowledge of Core Concepts) recorded an attainment level of 78%, indicating that a majority of students demonstrated strong theoretical understanding of Technology Management principles. This suggests that the current teaching and assessment methods particularly quiz and examinations are effective in supporting cognitive learning.

For CLO2 (Analytical and Problem-Solving Skills), attainment was relatively lower at 72%. While this is considered satisfactory, it highlights the need for greater emphasis on applied learning strategies. The results suggest that while students can comprehend theoretical concepts, they face challenges when transferring this knowledge to solve complex, real-world problems. This gap underscores the importance of embedding case-based learning, simulations, and industry-linked projects to strengthen analytical competencies.

In contrast, CLO3 (Communication and Soft Skills) achieved the highest attainment at 81%. Students performed strongly in teamwork, presentations, and participation activities. The findings confirm that rubric-based assessments are effective for evaluating soft skills, as they provide structured criteria and transparency in grading. This outcome also reflects the growing confidence of students in engaging with peers, delivering oral presentations, and demonstrating social responsibility within collaborative tasks.

Student Feedback

The qualitative analysis of student feedback provided further insights into the attainment results. On the 5-point Likert scale, students rated CLO clarity (M = 4.3) and relevance (M = 4.2) positively, suggesting that learning outcomes were well articulated and aligned with course objectives. However, the rating for feedback usefulness (M = 4.0) was comparatively lower. This indicates that while students recognized the value of assessments, they perceived a gap in receiving timely and constructive feedback that could better guide their learning progression.

Open-ended responses highlighted three recurring themes:

- Demand for more interactive activities such as discussions, and group-based problem-solving.
- Industry relevance, where students expressed a preference for case studies, guest lectures, and assignments linked to real-world challenges.
- Digital learning tools, including the use of online platforms, simulations, and analytics dashboards to support engagement and personalized learning.

These findings suggest that while CLOs are clearly defined and aligned with teaching strategies, the delivery methods could be further enhanced to create a more engaging, applied, and technologically supported learning environment.

Pedagogical Implications

The findings carry several pedagogical implications for improving CLO attainment and strengthening assurance of learning: Project-Based and Case-Based Learning: Embedding real-world projects, simulations, and industry-linked case studies can bridge the gap between theoretical understanding and analytical problem-solving. This approach would directly address the moderate attainment observed for CLO2. Formative Feedback Mechanisms: Introducing structured feedback loops—such as peer review, draft submissions, and digital feedback tools—can enhance the usefulness of feedback and support students' continuous learning process.

Digital Integration: Leveraging digital platforms, interactive learning tools, and analytics dashboards can improve student engagement and provide personalized insights into learning progress. Foresight-Oriented Competencies: Incorporating elements of strategic foresight and scenario planning can better prepare students for uncertain and rapidly evolving professional environments. By linking CLOs with future-oriented skills, the course can strengthen its relevance for the Fourth Industrial Revolution.

Overall, the results demonstrate that students achieved satisfactory to high levels of CLO attainment, with notable strengths in communication and soft skills. However, the moderate performance in analytical problem-solving highlights the need for pedagogical innovation to strengthen application-oriented learning. Student feedback reinforces this conclusion, emphasizing the demand for more interactive, industry-relevant, and digitally integrated approaches. Collectively, these findings contribute to continuous quality improvement efforts by identifying both areas of success and opportunities for further enhancement.

CONCLUSION

This study examined the measurement of Course Learning Outcomes (CLOs) in an undergraduate Technology Management course, offering insights into both strengths and areas for improvement. The findings indicate that students performed well in foundational knowledge and communication/soft skills, reflecting the effectiveness of current assessment approaches for cognitive and affective domains. However, the moderate attainment in analytical and problem-solving skills underscores the need for more applied and project- based pedagogical strategies that better bridge theory with practice.

Student feedback further reinforced this conclusion, emphasizing the importance of interactivity, industry relevance, and digital integration in teaching and assessment. These insights point to the value of incorporating case-based learning, simulations, and foresight- oriented tools that not only improve CLO attainment but also prepare students for the dynamic challenges of the Fourth Industrial Revolution. The contribution of this study lies in its evidence-based recommendations for enhancing CLO measurement in interdisciplinary contexts. By adopting rubrics for soft skills, embedding digital platforms for real-time analytics, and promoting interactive pedagogies, higher education institutions can strengthen both the accuracy of CLO assessment and the overall quality of student learning.

Although the study was conducted within the Malaysian higher education system, its implications extend more broadly. Institutions worldwide that are committed to strengthening Outcome-Based Education (OBE) and ensuring graduate employability can draw lessons from these findings. Ultimately, effective CLO measurement is not merely a compliance requirement for accreditation but a powerful mechanism for fostering continuous quality improvement, advancing pedagogical innovation, and equipping graduates with the competencies required to thrive in a rapidly changing global landscape.

ACKNOWLEDGEMENT

The study was supported by the Multidisciplinary Research Grant (MDR): Q738 by University Tun Hussein Onn Malaysia

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