Research Paper

Developing A Learning Outcomes Assessment Model for Geological Engineering Education Based on OBE and CQI Framework

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Abstract

International accreditation frameworks require engineering programs to demonstrate systematic assessment of Program Learning Outcomes (PLOs) to ensure graduates achieve global competencies. However, many institutions, including engineering programs in Indonesia, still face challenges in operationalizing outcome-based assessments due to fragmented data, inconsistent documentation, and limited feedback mechanisms. To address this gap, this study aimed to develop a PLO assessment model for geological engineering education based on Outcome-Based Education (OBE) and Continuous Quality Improvement (CQI). The research employed a research and development (R&D) approach, incorporating elements of action research and integrated gap analysis, readiness assessment, and prototype system development. The model was designed following the Plan–Do–Check–Act (PDCA) cycle and operationalized through a prototype information system constructed with PHP and a centralized database. Data were collected through a literature review, stakeholder interviews, and document analysis. The system was tested using black-box testing and evaluated through faculty feedback. The findings revealed that the model effectively linked Course Learning Outcomes (CLOs) to PLOs, automated reporting processes, and reduced administrative burdens in preparing accreditation documentation.

Furthermore, the integration of CQI ensured that assessment data were continuously used for curriculum improvements, thereby embedding a culture of sustainable quality assurance. The study contributes to both theoretical and practical domains by bridging curriculum design, assessment practices, and accreditation requirements. While the prototype requires further refinement and scaling, the model provides a replicable framework for engineering programs preparing for international accreditation and for producing globally competent graduates.

Keywords: *Program Learning Outcomes, Outcome-Based Education, Continuous Quality Improvement*

INTRODUCTION

Higher education institutions, particularly in engineering disciplines, are increasingly required to demonstrate accountability and global competitiveness. One of the most critical elements in this regard is the ability to systematically assess the extent to which graduates achieve the intended program learning outcomes (PLOs). In the global landscape of engineering education, accreditation bodies such as ABET (United States), JABEE (Japan), and the Indonesian Accreditation Board for Engineering Education (IABEE) place strong emphasis on outcome-based accreditation systems that ensure graduates possess the competencies needed for professional practice. The implementation of Outcome-Based Education (OBE), therefore, becomes central to engineering programs seeking international recognition, as it shifts the focus from teaching inputs to measurable student outcomes (Syeed et al., 2022; Pradhan, 2021).

Despite its significance, many engineering programs in Indonesia still face challenges in operationalizing the assessment of PLOs. Traditional approaches often rely on fragmented and

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manual evaluations that make it difficult to track and demonstrate continuous achievement across courses and curriculum levels. As a result, institutions encounter difficulties in establishing clear linkages between course learning outcomes (CLOs) and PLOs, which in turn hampers their ability to present evidence of systematic quality assurance. Studies in other contexts have shown that the lack of readiness in managing outcome-based assessments is a common obstacle, especially when data integration and documentation systems are not fully developed (Abou-Zeid & Taha, 2014).

The Continuous Quality Improvement (CQI) framework offers an effective mechanism to support such integration. By adopting the Plan–Do–Check–Act (PDCA) cycle, CQI ensures that assessment data are not merely collected but are analyzed and used to inform curricular adjustments, teaching improvements, and strategic decision-making. Embedding CQI principles into the assessment of learning outcomes strengthens the institutional culture of quality. It ensures that evaluation is not a one-time activity but a sustainable and iterative process (Liew et al., 2021).

This study aims to develop a model for assessing program learning outcomes in geological engineering education that is explicitly grounded in OBE and CQI principles. The model is designed to provide a systematic pathway from CLOs to PLOs, supported by a prototype information system to enhance transparency and efficiency. By focusing on geological engineering as a case study, the research contributes to both the theoretical discourse on learning outcomes assessment and the practical needs of programs preparing for international accreditation. Ultimately, the model seeks to bridge the gap between curriculum design, assessment practices, and quality assurance, thereby strengthening the capacity of engineering programs to produce graduates who are globally competent and industry-ready (Busaidi, 2020; Allahverdi et al., 2021).

LITERATURE REVIEW

International Accreditation and Learning Outcomes Assessment

International accreditation in engineering education plays a pivotal role in ensuring that programs align with globally recognized standards of quality. Bodies such as ABET in the United States, JABEE in Japan, and IABEE in Indonesia emphasize outcome-based accreditation systems, which require evidence that graduates achieve predefined competencies. Accreditation, therefore, not only validates the academic quality of a program but also enhances the global competitiveness of its graduates (Allahverdi et al., 2021). The benefits of accreditation extend beyond institutional recognition; it enhances the employability of graduates in the international job market and assures that the program meets rigorous quality benchmarks (Busaidi, 2020). However, challenges persist in many contexts, as institutions often struggle with documentation, data integration, and readiness in meeting the demanding requirements of international accreditation (Abou-Zeid & Taha, 2014).

Outcome-Based Education (OBE)

Outcome-Based Education (OBE) represents a paradigm shift from traditional input-oriented approaches to learning outcomes-focused frameworks. In OBE, the design of curriculum, instructional strategies, and assessments is guided by clearly defined learning outcomes, ensuring that students acquire both technical and non-technical competencies required by industry and society (Syeed et al., 2022; Pradhan, 2021). For engineering programs, OBE is particularly significant as it aligns academic preparation with global standards, such as the Washington Accord, thereby enhancing graduate attributes. The practical implementation of OBE requires systematic curriculum mapping, transparent assessment mechanisms, and strong linkages between Course Learning Outcomes (CLOs) and Program Learning Outcomes (PLOs). Previous studies have highlighted that without robust assessment systems, the operationalization of OBE often remains superficial and fails to demonstrate measurable improvement in graduate competencies (Shah & Kolhekar, 2021; Dai et al., 2017).

Continuous Quality Improvement (CQI)

Continuous Quality Improvement (CQI) is a quality assurance approach that emphasizes iterative evaluation and enhancement of educational processes. Rooted in the Plan–Do–Check–Act (PDCA) cycle, CQI ensures that outcome assessments are not static but continuously inform program improvements (Liew et al., 2021). In engineering education, the integration of CQI with OBE is crucial for sustaining quality and meeting the dynamic demands of the industry (Tshai et al., 2014). Studies show that embedding CQI into outcome assessment contributes to stronger institutional cultures of accountability and responsiveness (Mirza & Javed, 2022; Aithal & Maiya, 2023). By ensuring that assessment results are systematically fed back into curriculum development, teaching strategies, and stakeholder engagement, CQI transforms assessment from a compliance activity into a strategic tool for long-term quality assurance.

Assessment Models for Program Learning Outcomes

The assessment of Program Learning Outcomes (PLOs) is a central requirement in OBE and international accreditation. Effective models emphasize traceability, where student achievement is measured from CLOs at the course level to PLOs at the program level. Several approaches have been developed, including rubric-based assessments, electronic portfolios, and integrated information systems that automate data collection and analysis (Safiudin et al., 2020). Research also underscores the importance of involving stakeholders—faculty, students, and industry—in defining and evaluating learning outcomes to ensure relevance and alignment with professional standards (Han et al., 2024). In practice, institutions that fail to establish coherent PLO assessment models often face challenges in accreditation reviews, as they cannot adequately demonstrate evidence of student achievement and continuous improvement (Li & Lei, 2015).

Taken together, the literature highlights three key imperatives: (1) alignment of accreditation requirements with OBE principles, (2) integration of CQI mechanisms into assessment practices, and (3) development of systematic models to assess and document PLO achievement. Building on this foundation, the present study contributes by proposing a PLO assessment model in geological engineering education that integrates OBE and CQI frameworks, supported by an information system prototype designed to enhance transparency and accountability.

RESEARCH METHOD

This study employed a research and development (R&D) approach combined with elements of action research to design and validate a model for assessing program learning outcomes (PLOs) in geological engineering education. The methodology was guided by the principles of Outcome-Based Education (OBE) and Continuous Quality Improvement (CQI), ensuring that the model would be both pedagogically relevant and practically applicable within the framework of international accreditation.

Research Design

The research was conducted in two major phases. The first phase involved a comprehensive needs analysis to identify gaps in the existing quality assurance system in relation to the IABEE criteria. Data were collected through literature review, document analysis, and interviews with key stakeholders, including faculty members, students, and academic administrators. The second phase focused on designing, prototyping, and internally validating a PLO assessment model and its supporting information system. This iterative process allowed for stakeholder feedback and refinement of the model to ensure its usability and alignment with accreditation standards.

Data Collection

Three primary methods were used for data collection:

1. Literature Review – International standards of accreditation (e.g., IABEE, ABET), theoretical foundations of OBE and CQI, and existing studies on PLO assessment systems were reviewed to inform the design of the model (Allahverdi et al., 2021; Li & Lei, 2015).
2. Interviews – Semi-structured interviews were conducted with program stakeholders to gather insights into the current challenges and expectations for PLO assessment.
3. Readiness Assessment – A structured instrument based on IABEE criteria was administered to evaluate the preparedness of the Geological Engineering Program in systematically assessing learning outcomes.

System Development Method

The model was developed using a prototype-based software development methodology within the Software Development Life Cycle (SDLC). The development process followed several iterative stages:

1. Communication and Requirement Analysis – Identification of user needs, including the ability to map Course Learning Outcomes (CLOs) to PLOs and to generate automated reports for accreditation purposes.
2. Quick Planning – Drafting of preliminary designs and system features in consultation with users.
3. Modeling and Quick Design – Creation of diagrams and flowcharts to represent the logical and physical structure of the assessment system.
4. Prototype Construction – Development of a working prototype using PHP programming language and a centralized database to support data storage and retrieval.
5. Deployment and Feedback – Presentation of the prototype to stakeholders, collection of feedback, and subsequent iterations of refinement until the system met user expectations.

Data Analysis

The analysis was conducted at two levels. First, thematic analysis was applied to qualitative data from interviews to identify recurring patterns, challenges, and stakeholder expectations. Second, gap analysis was performed by comparing current practices with IABEE accreditation standards to identify critical areas for improvement. The prototype system was then evaluated using black box testing, focusing on functionality, reliability, and user satisfaction.

CQI Framework Integration

The methodological design was explicitly aligned with the Plan–Do–Check–Act (PDCA) cycle as a CQI mechanism. In this context, the Plan phase involved defining the model requirements and learning outcomes; the Do phase corresponded to system development and implementation; the Check phase focused on testing and validation of the prototype; and the Act phase incorporated stakeholder feedback to revise and improve the system. This iterative CQI cycle ensured that the PLO assessment model was not static but continuously refined to meet accreditation and institutional needs (Liew et al., 2021; Tshai et al., 2014).

Through this methodology, the study ensured that the developed PLO assessment model was theoretically grounded, contextually relevant, and practically validated, making it a feasible tool for supporting international accreditation in geological engineering education.

FINDINGS AND DISCUSSION

Findings

1. Gap Analysis and Readiness Assessment

The readiness assessment revealed that the Geological Engineering Program at Universitas Pembangunan Nasional "Veteran" Yogyakarta faced several challenges in demonstrating systematic assessment of Program Learning Outcomes (PLOs). The primary gaps included:

a. Fragmented assessment data that limited the ability to track student achievement across courses.
b. Inconsistent documentation of Course Learning Outcomes (CLOs) to PLO mappings.
c. Limited feedback mechanisms, which hindered continuous quality improvement efforts.

These findings are consistent with earlier studies indicating that many engineering programs struggle with outcome assessment due to inadequate integration of data and processes (Abou-Zeid & Taha, 2014). The readiness assessment underscored the urgency of developing an integrated and transparent model that can align CLOs, Course Performance Indicators, and PLOs.

2. Prototype Development

Based on stakeholder consultations, a prototype information system was developed to automate and streamline the assessment process. The system allowed faculty to:

a. Input course-level assessment data (CLOs and their achievement indicators).
b. Map CLO achievements to PLOs using predefined weightings.
c. Generate automatic reports that summarize student achievement at both the course and program levels.

The interface was intentionally designed to be simple and user-friendly, ensuring accessibility for faculty members who may not be familiar with complex information systems. The system was constructed using PHP for its flexibility and adaptability, while a centralized database was employed to ensure consistent storage of assessment data.

3. System Testing and Feedback

The prototype underwent black box testing to verify functionality, including input validation, report generation, and CLO–PLO mapping accuracy. Early testing confirmed that the system was able to:

a. Efficiently generate automated reports of PLO achievement.
b. Reduce manual workload for faculty in preparing accreditation documentation.
c. Improve transparency in aligning CLOs with PLOs.

Feedback from faculty indicated that the prototype simplified the process of documenting outcomes and provided a clear structure for evaluating course contributions to program outcomes. Some recommendations were made to enhance system flexibility, such as adding options for customized rubrics and integrating more advanced visualization of PLO achievement.

Discussion

The development of the PLO assessment model and its supporting system demonstrated the feasibility of integrating OBE and CQI frameworks into the quality assurance processes of an engineering program. The findings highlight several important implications:

a. Bridging the Gap Between CLOs and PLOs

The system operationalized the theoretical linkages between course-level learning outcomes and program-level competencies. This addresses one of the most persistent challenges in outcome-based education, namely the lack of evidence connecting course delivery to graduate attributes (Syeed et al., 2022).

b. Embedding CQI into Assessment Practices

By adopting the PDCA cycle, the system ensured that assessment results were not static but were continually fed into improvement cycles. Faculty were able to use assessment reports to identify weaknesses, adjust course designs, and revise teaching strategies. This iterative process is aligned with global best practices in accreditation and quality assurance (Liew et al., 2021).

c. Efficiency and Transparency for Accreditation

The automation of outcome assessment facilitated the preparation of evidence for IABEE accreditation. The prototype system reduced administrative burden, improved accuracy in documenting achievement, and provided standardized reports that could be directly used in accreditation submissions. This strengthens institutional readiness for international accreditation, consistent with findings by Allahverdi et al. (2021) and Busaidi (2020).

d. Stakeholder Engagement and Usability

The involvement of faculty throughout the prototype development process ensured that the system was responsive to user needs. Usability feedback confirmed that simplicity and transparency were critical factors for successful adoption. This aligns with earlier research showing that stakeholder participation is vital in sustaining OBE–CQI integration (Han et al., 2024).

Overall, the findings suggest that the proposed PLO assessment model not only addresses existing gaps in quality assurance but also provides a scalable solution that could be replicated across other engineering programs in Indonesia. By bridging curriculum design, learning outcomes assessment, and accreditation documentation, the model contributes to building a culture of evidence-based continuous improvement in engineering education.

CONCLUSIONS

This study developed a model for assessing Program Learning Outcomes (PLOs) in geological engineering education, grounded in the principles of Outcome-Based Education (OBE) and Continuous Quality Improvement (CQI). The model was operationalized through the design and prototyping of an information system that enables systematic mapping of Course Learning Outcomes (CLOs) to PLOs, automated report generation, and integration into quality assurance processes. The findings highlight three key contributions:

Systematic Alignment of CLOs and PLOs, Integration of CQI through PDCA Cycle, and Practical Support for International Accreditation. The development and preliminary testing of the prototype system demonstrated that such a model can enhance efficiency, reliability, and accountability in learning outcomes assessment. Faculty feedback confirmed the usability and relevance of the system, while black box testing verified its functionality in generating accurate and comprehensive reports.

In conclusion, the proposed model represents a promising step towards strengthening the culture of evidence-based quality assurance in engineering education. By linking OBE and CQI in a practical and technology-supported framework, it not only enhances institutional capacity for international accreditation but also contributes to the broader mission of preparing globally competent graduates in geological engineering.

LIMITATIONS & FURTHER RESEARCH

Nevertheless, this study also faced several limitations. The prototype was tested primarily within a single program and with a limited set of courses, which restricts the generalizability of the results. Additionally, the system has not yet been integrated with broader institutional platforms, such as university-wide learning management or accreditation systems.

Future research should therefore focus on:

a. Advanced Analytics – Incorporating data analytics and visualization features to provide deeper insights into learning outcomes achievement and continuous improvement trends.
b. Longitudinal Studies – Conducting multi-year evaluations to examine how the model contributes to sustained improvement and accreditation success.

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