EFFECTIVENESS OF PROJECT-BASED LEARNING ON COURSE LEARNING OUTCOMES IN OUTCOME-BASED EDUCATION

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Abstract
Implementing the *Outcome-Based Education* (OBE) curriculum requires learning strategies that can comprehensively assess students' achievement of learning outcomes. This study aimed to evaluate the effectiveness of the *Project-Based Learning* (*PjBL)* model in achieving *Course Learning Outcomes* (CLOs) within the OBE framework in the DC Electrical Circuits and Electric Motor Control Practicum courses. This study employed a quantitative approach using a descriptive-evaluative method. The research sample consisted of 32 students from the Electrical Engineering Education Study Program at Universitas Islam Negeri Ar-Raniry. Data were collected through assessment instruments measuring students' attitudes, practical skills, and knowledge based on the CLO indicators specified in the Semester Learning Plan and were analyzed using descriptive quantitative techniques. The results showed that implementing the PjBL model resulted in an overall CLO achievement of 84.35%, which falls into the high category. The DC Electrical Circuits course achieved 82.85%, while the Electric Motor Control Practicum course achieved 85.85%. These findings indicate that PjBL effectively supports the achievement of Course Learning Outcomes within the Outcome-Based Education framework through project-oriented learning in electrical engineering education.

Keywords*:* Project-Based Learning, Outcome-Based Education, Electrical Engineering Education, DC Electrical Circuits, Electric Motor Control Practicum.

INTRODUCTION

The transformation of higher education requires universities to produce graduates who possess not only strong disciplinary knowledge but also practical skills, professional attitudes, critical thinking, communication, collaboration, and problem-solving abilities that meet the demands of the modern workforce (Novitasari et al., 2024). To address these challenges, many higher education institutions have adopted the OBE approach, which emphasizes achieving intended learning outcomes as the foundation for curriculum design, instructional implementation, assessment, and continuous improvement. Within this framework, CLOs specify the competencies students are expected to demonstrate upon completing a course and serve as a key basis for evaluating the extent to which intended learning outcomes have been achieved (Tho et al., 2021; Dewi, 2022).

A central requirement of OBE implementation is the alignment between intended learning outcomes, learning activities, and assessment practices. In this regard, learning activities should support CLO achievement by giving students opportunities to develop the targeted competencies, and

assessment practices should generate appropriate evidence of their achievement. This perspective is consistent with the principle of constructive alignment, in which intended learning outcomes, teaching and learning activities, and assessment tasks are systematically aligned. Therefore, within an OBE framework, CLO evaluation should not rely exclusively on students' final academic performance but should consider assessment evidence that reflects the different dimensions of the competencies specified in the intended learning outcomes. Such alignment is particularly relevant in engineering education, where students are expected to demonstrate the integration of disciplinary knowledge, practical competence, problem-solving ability, and professional attitudes.

One instructional model that aligns with these principles is PjBL. This approach provides students with opportunities to learn by completing projects related to real-world problems, enabling them to integrate conceptual understanding with practical skills, critical thinking, communication, and teamwork (Lubis et al., 2024). Consequently, PjBL is considered particularly suitable for engineering education, where students are expected to develop comprehensive competencies through authentic learning experiences (Aprilina, 2024). From an OBE perspective, PjBL is relevant not only because it uses projects as learning activities but also because it gives students opportunities to demonstrate the competencies represented in the targeted CLOs. Accordingly, the effectiveness of PjBL in supporting CLO achievement should be evaluated through assessment practices that are aligned with both the intended learning outcomes and the competencies developed during project-based activities.

In the Electrical Engineering Education Study Program, the DC Electrical Circuits and Electric Motor Control Practicum courses emphasize both conceptual understanding and practical competence. The DC Electrical Circuits course equips students with the ability to analyze the characteristics of direct current circuits and apply fundamental electrical principles to solve engineering problems. Meanwhile, the Electric Motor Control Practicum focuses on developing students' competencies in designing, operating, and evaluating electric motor control systems while complying with operational procedures and safety standards. The characteristics of these two courses require students to demonstrate the integration of knowledge, practical skills, and professional attitudes to achieve the intended learning outcomes. Therefore, the two courses provide a relevant context for implementing Project-Based Learning and evaluating CLO achievement across multiple learning domains (Akhyar et al., 2024).

Based on preliminary observations conducted during the implementation of these two courses, the learning process had adopted the OBE curriculum. However, the evaluation of CLOs was still predominantly based on students' final academic performance. Although students' attitudes and practical skills were assessed through laboratory activities and project-based assignments, these assessments had not been integrated to provide a comprehensive evaluation of CLO achievement in each course. This highlights a key challenge in implementing OBE: intended learning outcomes may encompass competencies that a single assessment cannot adequately capture. A more holistic evaluation framework is therefore needed to integrate the three domains of learning—attitudes, practical skills, and knowledge—to provide more comprehensive evidence of students' achievement of the intended learning outcomes and strengthen alignment among CLOs, learning activities, and assessment practices.

Previous studies have demonstrated that PjBL can support students' academic achievement, practical skills, critical thinking, and collaborative abilities in engineering education (Dwiantoro & Basuki, 2021; Akhyar et al., 2024; Lubis et al., 2024). These findings indicate that PjBL provides a learning context that can facilitate the development of multiple competencies relevant to engineering education. However, previous studies have frequently focused on particular learning outcomes, such as academic achievement, practical competence, critical thinking, or collaborative ability. Consequently, evidence on how multiple learning domains can be integrated to evaluate Course

Learning Outcome achievement within an explicit Outcome-Based Education framework remains limited. In particular, studies evaluating CLO achievement by simultaneously considering the three learning domains—attitudes, practical skills, and knowledge—across multiple electrical engineering courses remain limited (Sakdiah et al., 2025).

This gap is theoretically relevant because implementing OBE requires a clear relationship between the competencies specified in the CLOs, the learning activities designed to support those competencies, and the assessment evidence used to evaluate their achievement. Empirically, the present study contributes by integrating assessments of attitudes, practical skills, and knowledge to evaluate CLO achievement in two electrical engineering courses with different learning characteristics. The study therefore positions Project-Based Learning not only as an instructional approach but also as a learning context through which the alignment between intended CLOs, project-based learning activities, and multidimensional assessment can be evaluated.

Therefore, this study aims to evaluate the effectiveness of Project-Based Learning on CLOs within the OBE framework in the DC Electrical Circuits and Electric Motor Control Practicum courses. The evaluation focuses on students' achievement in the domains of attitudes, practical skills, and knowledge. Given the study's descriptive-evaluative design, the findings provide empirical evidence of the level of CLO achievement observed after implementing PjBL, rather than establishing a definitive causal relationship between PjBL and student learning outcomes. The findings are expected to contribute to improving OBE-oriented teaching and assessment practices in the Electrical Engineering Education Study Program by providing a multidimensional approach to evaluating CLO achievement.

RESEARCH METHODS

This study used a quantitative descriptive-evaluative design to evaluate the achievement of selected CLOs after implementing PjBL in the DC Electrical Circuits and Electric Motor Control Practicum courses. The evaluation focused on describing students' achievement of the targeted CLOs based on assessment evidence obtained from three learning domains: attitudes, practical skills, and knowledge. PjBL provided the learning context in which students engaged in project activities relevant to the competencies targeted in each course. Project-based learning has been widely implemented in technical and vocational education because it enables students to integrate theoretical knowledge with practical activities through project implementation (Akhyar et al., 2024).

This study was conducted within the OBE framework, in which learning outcomes serve as the basis for organizing learning activities and evaluating student achievement. Accordingly, the selected CLOs were used as the reference for identifying relevant learning activities and assessment evidence. The evaluation did not rely solely on students' final academic performance; it also considered attitudes, practical skills, and knowledge as complementary dimensions of CLO achievement.

The study did not employ an experimental or quasi-experimental design because no control group, random assignment, or pre-intervention measurement was included. Therefore, the findings were not interpreted as evidence of a definitive causal effect of PjBL on student learning outcomes. Instead, the study evaluated the level of CLO achievement observed after implementing PjBL within the existing learning context. Accordingly, the term *effectiveness* in this study refers to the extent to which the targeted CLOs were achieved within the learning context in which PjBL was implemented.

The population consisted of 119 undergraduate students enrolled in the Electrical Engineering Education Study Program. A total of 32 students were selected as research participants using purposive sampling. This sampling technique was applied because the study specifically evaluated students who participated in the DC Electrical Circuits and Electric Motor Control Practicum courses

in which PjBL was implemented and for whom assessment data related to the targeted CLOs were available. The sample consisted of 17 students enrolled in the DC Electrical Circuits course and 15 students enrolled in the Electric Motor Control Practicum course. The distribution of research participants is presented in Table 1.

Table 1. Distribution of Research Participants

No.	Course	Sample	Sampling Technique
1	DC Electrical Circuits	17	Purposive sampling
2	Electric Motor Control Practicum	15	Purposive sampling
	Total	32	

The study evaluated selected CLOs directly associated with implementing PjBL in the two courses. In the DC Electrical Circuits course, CLO 3 was selected for evaluation because the learning activities required students to apply electrical circuit concepts through project-oriented tasks. In the Electric Motor Control Practicum course, CLO 4 was selected because the targeted competency involved practical and project-based activities related to electric motor control systems. The evaluation considered evidence from attitudes, practical skills, and knowledge to provide a broader representation of students' achievement of the targeted learning outcomes.

Table 2. Targeted Course Learning Outcomes and Evaluation Context

Course	Targeted CLO	CLO Description	PjBL Learning Context	Learning Domains Evaluated
DC Electrical Circuits	CLO 3	[Insert the official CLO 3 description]	Project activities involving circuit analysis, implementation, testing, and problem-solving	Attitudes, practical skills, and knowledge
Electric Motor Control Practicum	CLO 4	[Insert the official CLO 4 description]	Project activities involving the design, operation, testing, and evaluation of electric motor control systems	Attitudes, practical skills, and knowledge

The descriptions of CLO 3 and CLO 4 should correspond exactly to the official course learning outcomes stated in the course syllabus. The selected CLOs were then linked to the learning activities implemented through PjBL and to the assessment instruments used to collect evidence of student achievement.

In this study, PjBL was not treated as an independent variable whose causal effect was experimentally tested. Rather, PjBL served as the instructional context in which students participated in activities that enabled them to demonstrate competencies associated with the targeted CLOs. Project activities required students to apply knowledge, perform practical tasks, collaborate during learning activities, and complete project-related assignments. These learning characteristics make

PjBL relevant to technical and vocational education, particularly in learning environments that require integrating conceptual understanding and practical competence (Akhyar et al., 2024).

The assessment process was organized according to the learning domains evaluated in the selected CLOs. The researchers assessed students' attitudes through observation during learning and project activities. Practical skills were assessed through students' demonstrated performance during practical and project implementation activities. Knowledge was assessed using course examinations. Table 3 presents the relationship between the targeted CLOs, PjBL activities, learning domains, and assessment instruments.

Table 3. Alignment between Course Learning Outcomes, Project-Based Learning Activities, and Assessment Instruments

Course	Targeted CLO	Project-Based Learning Activities	Learning Domain	Assessment Instrument
DC Electrical Circuits	CLO 3	Project planning, circuit analysis, implementation, testing, and problem-solving	Attitudes	Attitude observation sheet
DC Electrical Circuits	CLO 3	Circuit implementation, equipment operation, testing, and troubleshooting	Practical skills	Practical skills observation sheet
DC Electrical Circuits	CLO 3	Application and analysis of DC electrical circuit principles	Knowledge	Final Semester Examination
Electric Motor Control Practicum	CLO 4	Project planning, collaboration, implementation, and completion of motor control activities	Attitudes	Attitude observation sheet
Electric Motor Control Practicum	CLO 4	Design, wiring, operation, testing, and troubleshooting of motor control systems	Practical skills	Practical skills observation sheet
Electric Motor Control Practicum	CLO 4	Analysis and application of electric motor control principles	Knowledge	Final Practical Examination

As presented in Table 3, the evaluation framework linked the targeted CLOs with the learning activities implemented through PjBL and the assessment instruments used to collect evidence of

student achievement. This approach was intended to ensure that the assessment evidence corresponded to the competencies targeted in each course.

This study used three sources of assessment evidence: an attitude observation sheet, a practical skills observation sheet, and knowledge assessments. Using multiple assessment instruments was intended to provide a broader evaluation of CLO achievement because the competencies developed through project-based learning involved not only conceptual understanding but also practical performance and students' participation in learning activities.

The attitude observation sheet included 25 assessment items across six domains: discipline, responsibility, honesty, cooperation, self-confidence, and creativity and initiative. The observations were conducted during learning and project activities to document students' demonstrated attitudes and participation. Each assessment item was scored according to the scoring criteria applied in the course assessment system, and the resulting scores were included as one component of the CLO achievement evaluation.

The practical skills observation sheet was used to assess students' technical performance during practical and project-based activities. The assessment focused on students' demonstrated ability to perform technical activities relevant to the targeted CLOs, including preparing and using equipment and materials, implementing practical procedures, operating equipment or systems, completing technical tasks, testing, and problem-solving during project implementation.

Knowledge achievement was assessed using the course assessment instruments applied in each course. In the DC Electrical Circuits course, knowledge achievement was obtained from the Final Semester Examination. In the Electric Motor Control Practicum course, knowledge achievement was obtained from the Final Practical Examination. These assessments were used to evaluate students' understanding and application of concepts relevant to the targeted CLOs.

The three learning domains were used to provide complementary evidence of CLO achievement. The attitude observation provided evidence regarding students' participation and demonstrated behavior during learning activities; the practical skills assessment provided evidence regarding students' technical performance; and the knowledge assessment provided evidence regarding students' conceptual understanding and application.

The study interpreted the instruments' validity and reliability based on the documented instrument development and assessment procedures available in the study. No additional validity or reliability coefficients were generated retrospectively for the present analysis. Therefore, the study does not claim psychometric validation beyond the procedures documented in the original assessment process. The absence of additional psychometric evidence should be considered as a methodological limitation when interpreting the findings.

The research procedure began by identifying the CLOs targeted for evaluation based on the curriculum and course learning plans. The researchers then implemented relevant PjBL activities in the DC Electrical Circuits and Electric Motor Control Practicum courses. During the implementation of learning and project activities, students' attitudes and practical skills were assessed using observation instruments. Students' knowledge was subsequently assessed through the Final Semester Examination and Final Practical Examination. The assessment data obtained from the three learning domains were then compiled and analyzed descriptively to evaluate the achievement of the selected CLOs.

The collected data were analyzed using descriptive quantitative analysis. The analysis involved calculating the total score, mean score, percentage of CLO achievement, maximum score, and minimum score for each assessment domain to provide an overall description of students' CLO achievement in each course (Sugiyono, 2022).

The achievement of the attitude and practical skills domains was determined based on scores obtained from structured observation sheets using assessment rubrics developed according to the

targeted CLO indicators. Meanwhile, the knowledge domain was measured using students' scores on the Final Semester Examination (FSE) for the DC Electrical Circuits course and the Final Practical Examination (FPE) for the Electric Motor Control Practicum course.

The percentage of CLO achievement was calculated using the following equation:

$$\text{CLO Achievement (\%)} = \frac{\text{Score Obtained}}{Maximum\ Score}\ x\ 100\% \ldots\ldots (1)$$

Table 3. Classification Criteria for Course Learning Outcome (CLO) Achievement

CLO Achievement (%)	Achievement Level
≥ 85	Very High
70–84	High
55–69	Moderate
< 55	Low

The percentages of CPMK achievement obtained from the attitude, skills, and knowledge domains were subsequently classified based on the achievement criteria adopted from (Ristekdik, 2020). These criteria were used as a reference to determine CPMK achievement levels after implementing the PjBL model within the OBE framework in the DC Electrical Circuits and Electric Motor Control Practicum courses. Table 2 presents the achievement categories used in this study.

RESEARCH RESULTS AND DISCUSSION

This study evaluated CLO achievement in the DC Electrical Circuits and Electric Motor Control Practicum courses within the learning context in which PjBL was implemented. The evaluation focused on CLO 3 in the DC Electrical Circuits course and CLO 4 in the Electric Motor Control Practicum course, as these learning outcomes were addressed through project-based learning activities. The level of CLO achievement was assessed across three learning domains: attitudes, practical skills, and knowledge. The following sections present the results by learning domain.

Achievement of Students' Attitude Domain

Students' attitudes were assessed using an observation sheet throughout the implementation of PjBL activities. The assessment covered several indicators, including discipline, responsibility, teamwork, communication, and compliance with occupational health and safety (OHS) procedures during the learning process. The results of the attitude assessment for the DC Electrical Circuits and Electric Motor Control Practicum courses are presented in Table 4.

Table 4. Students' Attitude Achievement in the Evaluated Courses

Course	Number of Students	Mean Score	Percentage (%)	Achievement Level
DC Electrical Circuits	17	85.06	85.06	Very High
Electric Motor Control Practicum	15	87.73	87.73	Very High
Overall	32	86.31	86.31	Very High

Based on Table 4, the mean attitude achievement was 85.06% for the DC Electrical Circuits course and 87.73% for the Electric Motor Control Practicum course. Overall, the average attitude achievement across the evaluated courses reached 86.31%, which was classified as Very High.

The findings indicate that students demonstrated positive attitudes during the learning activities in which PjBL was implemented. The observation results showed that students demonstrated discipline, responsibility, teamwork, active communication, and compliance with occupational health and safety (OHS) procedures during project-related activities. The slightly higher attitude achievement observed in the Electric Motor Control Practicum course may be associated with differences in the characteristics of the learning activities and assessment context. However, the present study was not designed to determine the factors responsible for the observed difference between the two courses.

Overall, the findings indicate that high levels of attitude achievement were observed across both courses within the learning context in which Project-Based Learning was implemented. In addition to completing project-related tasks, students demonstrated professional behaviors corresponding to the attitude-related competencies assessed as part of the selected CLOs. These findings should be interpreted as evidence of observed attitude achievement within the evaluated learning context rather than as definitive evidence that PjBL alone caused the observed outcomes.

Achievement of Students' Practical Skills Domain

The practical skills domain was assessed using an observation sheet developed based on the targeted CLO indicators for each course. The assessment focused on students' ability to plan and implement project activities, use tools and materials appropriately, follow operational procedures, conduct testing, analyze results, and complete project tasks in accordance with the intended learning outcomes. Table 5 summarizes practical skills achievement in the DC Electrical Circuits and Electric Motor Control Practicum courses.

Table 5. Students' Practical Skills Achievement in the Evaluated Courses

Course	Number of Students	Mean Score	Percentage (%)	Achievement Level
DC Electrical Circuits	17	84.24	84.24	High
Electric Motor Control Practicum	15	84.67	84.67	High
Overall	32	84.44	84.44	High

Based on Table 5, the mean practical skills achievement was 84.24% for the DC Electrical Circuits course and 84.67% for the Electric Motor Control Practicum course. Overall, the average practical skills achievement across the evaluated courses reached 84.44%, which was classified as High.

The findings indicate that students demonstrated a high level of practical skills across both evaluated courses. This achievement was reflected in their demonstrated ability to plan project activities, perform laboratory work, operate equipment, conduct testing, analyze results, and complete project tasks in accordance with the targeted CLOs. The similar achievement levels observed between the two courses indicate that students demonstrated comparable practical performance within their respective learning contexts.

Within the learning context in which PjBL was implemented, the observed results provide evidence of practical skills achievement across both courses. However, because the present study did not employ an experimental or comparative design, the observed practical skills achievement cannot

be attributed exclusively to PjBL. Therefore, the findings should be interpreted as evidence of students' demonstrated practical skills within the evaluated learning context rather than as definitive evidence that PjBL alone caused the observed outcomes.

Achievement of Students' Knowledge Domain

The knowledge domain was assessed using the Final Semester Examination (FSE) for the DC Electrical Circuits course and the Final Practical Examination (FPE) for the Electric Motor Control Practicum course. The examination items were developed based on the targeted CLO indicators evaluated in each course. This assessment was intended to measure students' understanding of fundamental concepts, theoretical principles, and analytical abilities in accordance with the expected learning outcomes. A summary of the knowledge achievement results for the DC Electrical Circuits and Electric Motor Control Practicum courses is presented in Table 6.

Table 6. Students' Knowledge Achievement in the Evaluated Courses

Course	Number of Students	Mean Score	Percentage (%)	Achievement Level
DC Electrical Circuits	17	78.43	78.43	High
Electric Motor Control Practicum	15	85.15	85.15	Very High
Overall	32	81.58	81.58	High

Based on Table 6, the mean knowledge achievement was 78.43% for the DC Electrical Circuits course and 85.15% for the Electric Motor Control Practicum course. The overall average knowledge achievement across the evaluated courses was 81.58%, which was classified as High.

The findings indicate that students demonstrated the expected level of conceptual understanding in both courses. The higher knowledge achievement in the Electric Motor Control Practicum course indicates a difference in performance between the two evaluated courses. This difference may reflect variations in course characteristics, learning activities, student experiences, or assessment contexts. However, this study was not designed to identify the specific factors responsible for the observed difference.

Within the learning context in which PjBL was implemented, the observed results provide evidence of students' knowledge achievement in relation to the targeted CLOs. The findings should therefore be interpreted as evidence of observed knowledge achievement following the implementation of the evaluated learning activities rather than as definitive evidence that PjBL alone caused the observed outcomes.

Summary of Course Learning Outcome Achievement Based on Outcome-Based Education

Following analysis of the three assessment domains—attitudes, practical skills, and knowledge—a summary analysis was conducted to determine overall CLO achievement in the two evaluated courses. This analysis provides an overall picture of CLO achievement based on the assessment results obtained during the implementation of PjBL. Table 7 presents a summary of CLO achievement in the DC Electrical Circuits and Electric Motor Control Practicum courses.

Table 7. Summary of Course Learning Outcome Achievement Based on Three Assessment Domains

Course	CLO	Attitudes (%)	Practical Skills (%)	Knowledge (%)	Mean CLO Achievement (%)	Achievement Level
DC Electrical Circuits	CLO 3	85.06	85.06	78.43	82.85	High
Electric Motor Control Practicum	CLO 4	87.73	84.67	85.15	85.85	Very High
Overall		86.40	84.87	81.79	84.35	High

Based on Table 7, the mean CLO achievement in the DC Electrical Circuits course was 82.85%, categorized as High, while the Electric Motor Control Practicum course achieved 85.85%, categorized as Very High. Across both courses, the overall CLO achievement reached 84.35%, which falls within the High category.

The results indicate that implementing PjBL supported achievement of the targeted CLOs in both courses. The three assessment domains—attitudes, practical skills, and knowledge—showed achievement levels ranging from High to Very High. These findings suggest that PjBL can support not only students' conceptual understanding but also the development of practical competencies and professional attitudes aligned with the intended learning outcomes within the OBE framework.

Discussion

The findings indicate that implementing PjBL supported achievement of the intended CLOs in both the DC Electrical Circuits and Electric Motor Control Practicum courses. The overall CLO achievement was categorized as high, reaching 82.85% in DC Electrical Circuits and 85.85% in Electric Motor Control Practicum. Achievement across attitudes, practical skills, and knowledge was generally within the high to very high categories. These findings indicate that PjBL provided an integrated learning environment in which students could apply theoretical knowledge, perform technical tasks, and demonstrate professional attitudes through project activities. Similar findings have been reported in Indonesian technical education contexts, where PjBL has been associated with improved learning outcomes and student engagement in electrical engineering learning (Mangesa et al., 2024; Mustaqim et al., 2024).

High achievement in the attitude domain may reflect the collaborative, responsibility-oriented nature of project activities. Students were required to coordinate tasks, communicate with group members, complete assigned responsibilities, and follow laboratory procedures and safety standards. Thus, attitudes such as discipline, responsibility, teamwork, and communication were developed through direct participation in project completion rather than through theoretical instruction alone. This finding is consistent with (Ananto, 2022), who reported improvements in students' discipline and performance through PjBL in vocational technical education. In electrical engineering education, this behavioral development matters because technical competence must be paired with responsibility and adherence to safety procedures during practical work.

The high achievement in practical skills also demonstrates the relevance of PjBL to electrical engineering practicum. Through project activities, students were involved in planning, assembling, operating, testing, analyzing, and troubleshooting electrical systems. These activities required

students to translate theoretical concepts into practical performance and to respond to problems encountered during implementation. Candra et al. reported similar results, finding that PjBL was effective in electrical installation practice, while Mustaqim et al. (2024) demonstrated its applicability to electrical motor installation learning. Mangesa et al. (2024) also reported improved learning outcomes through PjBL in electrical power installation learning. These findings strengthen the interpretation that project-oriented activities are particularly relevant to technical subjects in which competence must be demonstrated through actual performance.

The knowledge achievement, which was also categorized as high to very high, indicates that the project-oriented approach did not appear to reduce students' conceptual learning. Instead, project activities may have enabled students to connect theoretical principles with observable practical outcomes. Students needed conceptual understanding to explain circuit behavior, interpret measurements, identify errors, and determine appropriate solutions during project implementation. The slightly higher knowledge achievement in the Electric Motor Control Practicum may reflect the direct link between control concepts and observable motor responses. However, this explanation should be interpreted cautiously because knowledge achievement was measured through the final examination and may also have been influenced by students' prior knowledge, other learning activities, and assessment characteristics. Research by Akhyar et al. (2024) also highlights the potential of project-oriented learning approaches to support learning outcomes in vocational education.

The findings further indicate the potential compatibility between PjBL and Outcome-Based Education (OBE). Project activities provide authentic contexts in which CLOs can be demonstrated through observable performance. Students can demonstrate knowledge through analysis and explanation, practical skills through project implementation and troubleshooting, and attitudes through teamwork, responsibility, communication, discipline, and safety practices. This integration is particularly relevant to OBE because it emphasizes measurable student competencies rather than learning activities alone. Project-based activities therefore connect assessment more directly to the competencies specified in the CLOs.

The relatively small difference in overall CLO achievement between DC Electrical Circuits (82.85%) and Electric Motor Control Practicum (85.85%) suggests that PjBL can be implemented across different electrical engineering practicum contexts. Nevertheless, the difference should not be interpreted as evidence that PjBL is more effective in one course than the other. Differences in course content, project complexity, students' prior knowledge, laboratory facilities, lecturer support, and assessment characteristics may contribute to variations in achievement. Therefore, the findings are better interpreted as indicating that the PjBL approach provided a supportive learning context for achieving CLOs in both courses.

Overall, the findings support using PjBL as an instructional approach to integrate knowledge, practical skills, and attitudes within OBE-oriented electrical engineering education. However, the findings should not be interpreted as definitive evidence that PjBL alone caused the observed achievement. The descriptive-evaluative design did not involve a comparison group or pre-intervention measurement, limiting causal interpretation. The results therefore provide evidence of CLO attainment following PjBL implementation rather than conclusive evidence of its causal effectiveness. Future studies should use quasi-experimental designs, pre-test and post-test measurements, or longitudinal approaches to examine PjBL's contribution to student learning outcomes more rigorously.

CONCLUSION

The findings show that implementing OBE through PjBL supported achievement of the targeted CLOs in the DC Electrical Circuits and Electric Motor Control Practicum courses. Overall CLO achievement reached 84.35%, categorized as High, with the highest achievement in the attitude domain (86.40%), followed by practical skills (84.87%) and knowledge (81.79%). These results indicate that students demonstrated not only adequate conceptual understanding but also practical competence and positive professional behaviors during project activities. The findings therefore suggest that PjBL provides a suitable learning context for integrating multiple dimensions of competence within an OBE-oriented electrical engineering curriculum.

Theoretically, this study contributes to understanding PjBL as a pedagogical approach that can operationalize OBE through authentic, competency-oriented learning activities. Project-based activities give students opportunities to demonstrate CLOs through observable performance, including applying knowledge, executing technical procedures, problem-solving, teamwork, responsibility, and compliance with safety practices. Thus, PjBL in this context extends beyond improving individual learning outcomes; it provides an instructional mechanism through which knowledge, practical skills, and attitudes can be developed and assessed as integrated components of engineering competence. This finding reinforces the relevance of PjBL for electrical engineering education, particularly in practicum courses where theoretical knowledge and practical performance need to be closely connected.

However, the findings should be interpreted within the study's limitations. The descriptive-evaluative design did not include a comparison group, pre-intervention measurement, or random assignment; therefore, the results cannot establish a definitive causal relationship between PjBL implementation and CLO achievement. In addition, the knowledge domain was assessed through final examinations, while attitudes and practical skills may have been influenced by the assessment context, lecturer support, student collaboration, prior knowledge, and laboratory conditions. Future research should employ quasi-experimental or longitudinal designs involving pre-test and post-test measurements and comparison groups to provide stronger evidence of the contribution of PjBL to CLO attainment. Further studies could also examine the transfer and retention of competencies developed through PjBL and investigate how specific project components, such as collaboration, troubleshooting, scaffolding, and authentic assessment, influence different dimensions of learning outcomes.

RECOMMENDATIONS

Based on the findings of this study, PjBL can be considered a relevant learning approach for supporting the achievement of CLOs within an OBE framework. In electrical engineering education, instructors are encouraged to develop projects that are contextual, technically relevant, and aligned with current industry needs so that students can gain meaningful learning experiences while developing both technical and professional competencies.

Assessment instruments should also be continuously refined to provide a more comprehensive measure of CLO achievement across attitudes, practical skills, and knowledge. Future research should involve larger samples, a wider range of courses, and comparative or experimental designs to provide stronger evidence on PjBL's contribution to CLO achievement and OBE implementation in higher education.

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