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Marzuki Abubakar
Editor in Chief

The Effectiveness of Project-Based Learning Model on Course Learning Outcomes Based on Outcome-Based Education in DC Electrical Circuits and Electrical Motor Control Practicum Course

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Abstract

The implementation of 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 the implementation of 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 is effective in supporting 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 Outcome-Based Education (OBE) approach, which emphasizes the achievement of learning outcomes as the foundation for curriculum design, instructional implementation, and assessment systems. Within this framework, Course Learning Outcomes (CLOs) serve as the primary indicators for evaluating the effectiveness of the teaching and learning process (Tho et al., 2021; Dewi, 2022).

One instructional model that aligns well with the principles of OBE is Project-Based Learning (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)..

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 make them well suited to the implementation of Project-Based Learning, as they require the integration of knowledge, practical skills, and professional attitudes to achieve the intended learning outcomes (Akhyar et al., 2024).

Based on preliminary observations conducted during the implementation of these two courses, the learning process had adopted the Outcome-Based Education (OBE) curriculum. However, the evaluation of Course Learning Outcomes (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 condition highlights the need for a more holistic evaluation framework that integrates the three domains of learning—attitudes, practical skills, and knowledge—to provide a more comprehensive assessment of students' achievement of the intended learning outcomes.

Previous studies have demonstrated that Project-Based Learning (PjBL) improves students' academic achievement, practical skills, critical thinking, and collaborative abilities in engineering education (Dwiantoro & Basuki, 2021; Akhyar et al., 2024; Lubis et al., 2024). Reported that integrating PjBL into an OBE framework facilitates the achievement of Course Learning Outcomes through competency-oriented assessment. Nevertheless, 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).

Therefore, this study aims to evaluate the achievement of Course Learning Outcomes (CLOs) within the Outcome-Based Education (OBE) framework through the implementation of Project-Based Learning (PjBL) in the DC Electrical Circuits and Electric Motor Control Practicum courses. The findings are expected to provide empirical evidence regarding students' achievement in the domains of attitudes, practical skills, and knowledge, while also serving as a basis for improving OBE-oriented teaching and assessment practices in the Electrical Engineering Education Study Program.

RESEARCH METHODS

This study employed a quantitative approach using a descriptive-evaluative research method. This method was applied to evaluate the achievement of Course Learning Outcomes (CLOs) within the Outcome-Based Education (OBE) framework following the implementation of the Project-Based Learning (PjBL) model in the DC Electrical Circuits and Electric Motor Control Practicum courses (Rahmi et al., 2024). The evaluation aimed to determine the extent to which the implementation of PjBL supported the achievement of the intended CLOs based on assessments of students' attitudes, practical skills, and knowledge.

The study population consisted of 119 active students enrolled in the Electrical Engineering Education Study Program. The research sample included 32 students, comprising 17 students enrolled in the DC Electrical Circuits course and 15 students enrolled in the Electric Motor Control Practicum course. The participants were selected using purposive sampling, with the inclusion criterion being students who participated in courses implemented using the Project-Based Learning model (Sugiyono, 2022).

The focus of the evaluation was the achievement of the Course Learning Outcomes in the two courses where Project-Based Learning had been implemented. In the DC Electrical Circuits course, the evaluation focused on CLO 3, which assesses students' ability to understand and analyze direct current (DC) electrical circuits using Ohm's Law and Kirchhoff's Laws. The achievement of this learning outcome was supported through project-based learning activities involving Operational Amplifier (Op-Amp) applications.

For the Electric Motor Control Practicum course, the evaluation focused on Course Learning Outcome (CLO) 4, which assesses students' ability to analyze the stability of control systems and evaluate

control parameters in electric motor control systems. This learning outcome was assessed through project-based activities involving the analysis and modeling of electrical, mechanical, electromechanical, and filter systems relevant to the course content. These CLOs were selected because they had been implemented using the Project-Based Learning (PjBL) model, allowing their achievement to be evaluated through the domains of attitudes, practical skills, and knowledge.

The variables examined in this study consisted of the implementation of the Project-Based Learning (PjBL) model as the evaluated instructional approach and the achievement of Course Learning Outcomes (CLOs) as the observed outcome. In the DC Electrical Circuits course, the evaluation focused on students' ability to test the functionality of electrical circuits and apply occupational safety procedures during learning activities and laboratory practice. In the Electric Motor Control Practicum course, the evaluation focused on students' ability to analyze control system stability and evaluate control parameters in electric motor control systems. The achievement of these CLOs was measured through three learning domains: attitudes, practical skills, and knowledge. Students' attitudes and practical skills were assessed using structured observation sheets during project-based learning activities, while the knowledge domain was assessed through the Final Semester Examination (FSE), with examination items developed based on the indicators of the evaluated Course Learning Outcomes.

The research instruments were developed based on the Course Learning Outcome (CLO) indicators specified for each course in accordance with the principles of Outcome-Based Education (OBE) (Rahmi et al., 2024). Three assessment instruments were employed in this study:

1) Attitude observation sheet, used to assess students' discipline, responsibility, teamwork, ethical behavior, and participation throughout the implementation of project-based learning activities.
2) Practical skills observation sheet, used to evaluate students' ability to plan, implement, operate, and complete project tasks in accordance with the targeted Course Learning Outcomes.
3) Knowledge assessment instrument, represented by 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 examination items were developed based on the evaluated Course Learning Outcome indicators to measure students' cognitive achievement.

Student Attitude Observation Sheet

Table 1. Student Attitude Observation Sheet

No	Observation Item	Score
A. Discipline		
1.	The student attends project-based learning activities on time.	1-4
2.	The student follows the rules and procedures during project implementation.	1-4
3.	The student completes assigned tasks according to the निर्धारित schedule.	1-4
4.	The student uses project working time effectively.	1-4
B. Responsibility		
5.	The student performs the tasks assigned as his/her responsibility.	1-4
6.	The student takes proper care of tools and materials during project implementation.	1-4
7.	The student is willing to correct mistakes made during the project.	1-4
8.	The student demonstrates commitment to completing the project.	1-4
C. Honesty		
9.	The student reports the work results according to the actual conditions.	1-4

10.	The student does not plagiarize the work of other groups.	1-4
11.	The student honestly reports problems encountered during the project.	1-4
12.	The student properly cites the references used.	1-4
D. Cooperation		
13.	The student actively cooperates with group members.	1-4
14.	The student respects the opinions of other group members.	1-4
15.	The student helps group members who experience difficulties.	1-4
16.	The student communicates effectively within the group.	1-4
E. Self-Confidence		
17.	The student is confident in expressing opinions during discussions.	1-4
18.	The student demonstrates confidence when presenting the project results.	1-4
19.	The student is able to answer questions appropriately.	1-4
20.	The student actively asks questions when experiencing difficulties.	1-4
F. Creativity and Initiative		
21.	The student demonstrates creative ideas during the project.	1-4
22.	The student demonstrates initiative in completing tasks.	1-4
23.	The student is able to find solutions to project-related problems.	1-4
24.	The student demonstrates innovation in carrying out the project.	1-4
25.	The student demonstrates enthusiasm for improving the project outcomes.	1-4

Student Skills Observation Sheet

Table 2. Student Skills Observation Sheet

No	Butir Observasi	Skor
A. Project Planning		
1.	The student is able to clearly determine the project objectives.	1-4
2.	The student develops project work procedures systematically.	1-4
3.	The student determines the tools and materials required for the project appropriately.	1-4
4.	The student develops a project implementation schedule based on the agreement among group members.	1-4
B. Project Implementation Process		
5.	The student carries out the project according to the established work procedures.	1-4
6.	The student demonstrates discipline during project implementation.	1-4
7.	The student is able to work collaboratively within the group.	1-4
8.	The student is able to complete assigned tasks on time.	1-4
9.	Mahasiswa The student is able to overcome problems encountered during project implementation.mengatasi kendala selama proyek berlangsung	
C. Technical Skills		
10.	The student demonstrates proficiency in using work tools.	1-4
11.	The student is able to use materials appropriately.	1-4
12.	The student applies work methods according to established procedures.	1-4

13.	The student applies Occupational Health and Safety (OHS) principles during project implementation.	1-4
D. Student Creativity		
14.	The student modifies the product according to project needs and proposes ideas different from the given example.	1-4
15.	The student demonstrates innovation in completing the project.	1-4
16.	The student is able to modify the design or work method.	1-4
17.	The student produces effective solutions to project-related problems.	
E. Final Project Product		
18.	The resulting product meets the project objectives.	1-4
19.	The product functions properly according to the established criteria.	1-4
20.	The product has quality and neatness that meet the standard of above 80%.	1-4
21.	The product is completed within the time.	1-4
F. Project Results Presentation		
22.	The student is able to explain the project results clearly.	1-4
23.	The student demonstrates mastery of the project-related material.	1-4
24.	The student is able to answer questions fluently and accurately.	1-4
25.	The student uses presentation media effectively.	1-4

The collected data were analyzed using descriptive quantitative analysis. The analysis involved calculating the total score, mean score, percentage of Course Learning Outcome (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 Course Learning Outcome (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 Course Learning Outcome (CLO) achievement was calculated using the following equation:

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

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 Ristekdikti (2020). These criteria were used as a reference to determine the level of CPMK achievement following the implementation of the Project-Based Learning (PjBL) model within the Outcome-Based Education (OBE) framework in the DC Electrical Circuits and Electric Motor Control Practicum courses. The achievement categories used in this study are presented in Table 2.

RESEARCH RESULTS AND DISCUSSION

Research Results

This study evaluated the achievement of Course Learning Outcomes (CLOs) following the implementation of the Project-Based Learning (PjBL) model in the DC Electrical Circuits and Electric Motor Control Practicum courses. 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 had been implemented using the PjBL approach. The level of CLO achievement was assessed across three learning domains: attitudes, practical skills, and knowledge. The results for each domain are presented in the following sections.

Achievement of Students' Attitude Domain

Students' attitudes were assessed using an observation sheet throughout the implementation of Project-Based Learning (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 score 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 both courses reached 86.31%, which falls into the Very High category.

These findings indicate that students demonstrated positive attitudes throughout the implementation of Project-Based Learning (PjBL). The observation results showed that students consistently exhibited discipline, responsibility, teamwork, active communication, and compliance with occupational health and safety (OHS) procedures during project activities. The slightly higher achievement observed in the Electric Motor Control Practicum course suggests that its hands-on learning environment, which requires greater collaboration and direct project implementation, contributed more effectively to the development of students' professional attitudes.

Overall, the findings suggest that the implementation of Project-Based Learning effectively supports the achievement of the attitude domain within the Outcome-Based Education (OBE) framework. In addition to completing project tasks, students demonstrated professional behaviors that align with the intended Course Learning Outcomes (CLOs).

Achievement of Students' Practical Skills Domain

The practical skills domain was assessed using an observation sheet developed based on the targeted Course Learning Outcome (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. A summary of the practical skills achievement in the DC Electrical Circuits and Electric Motor Control Practicum courses is presented in Table 5.

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 84.67% for the DC Electrical Circuits course and 84.67% for the Electric Motor Control Practicum course. Overall, the average practical skills achievement across both courses reached 84.44%, which is classified as High.

The findings indicate that most students were able to apply the knowledge acquired during the learning process to project implementation effectively. This was reflected in their ability to plan project activities, perform laboratory work, operate equipment correctly, conduct testing, analyze the results, and complete project reports in accordance with the targeted Course Learning Outcomes (CLOs). The relatively similar achievement levels between the two courses suggest that the implementation of Project-Based Learning (PjBL) provided comparable opportunities for students to develop practical competencies through authentic, project-oriented learning experiences.

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 Course Learning Outcome (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 both courses was 81.58%, which falls into the High category.

These findings indicate that students achieved the expected level of conceptual understanding in both courses. The higher score obtained in the Electric Motor Control Practicum course suggests that practical, project-oriented learning experiences enabled students to connect theoretical concepts with their real-world applications more effectively. As a result, students were better able to understand and apply the concepts assessed through the course learning outcomes (CLOs).

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

Following the analysis of the three assessment domains—attitudes, practical skills, and knowledge—a summary analysis was conducted to determine the overall achievement of the Course Learning Outcomes (CLOs) in the two evaluated courses. This analysis provides an overall picture of CLO achievement based on the assessment results obtained during the implementation of Project-Based Learning (PjBL). The summary of CLO achievement in the DC Electrical Circuits and Electric Motor Control Practicum courses is presented in Table 7.

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 the implementation of Project-Based Learning (PjBL) supported the 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 Outcome-Based Education (OBE) framework.

Discussion

The findings indicate that the implementation of *Project-Based Learning* (PjBL) supported the achievement of the intended Course Learning Outcomes (CLOs) in both the DC Electrical Circuits and Electric Motor Control Practicum courses. The achievement levels across attitudes, practical skills, and knowledge were generally within the high to very high categories, suggesting that project-based activities provided students with opportunities to develop multiple dimensions of competence simultaneously.

The attitude assessment showed high achievement in both courses. Students demonstrated responsibility, discipline, teamwork, communication, and compliance with work and laboratory safety procedures throughout the project activities. The collaborative nature of PjBL required students to coordinate tasks, discuss solutions, and take responsibility for completing project activities. These learning experiences may explain the strong performance in the attitude domain. This finding is consistent with Lubis et al. (2024), who reported that PjBL can promote student responsibility, communication, and collaboration through student-centered learning activities.

The practical skills results also indicate that students were able to apply their knowledge during project implementation. Students were involved in planning activities, operating equipment, assembling and testing circuits, analyzing results, and completing project tasks according to the targeted CLOs. The relatively similar achievement between the two courses suggests that PjBL provided students with sufficient opportunities to practice technical skills through direct and contextual learning experiences. This finding supports Akhyar et al. (2024), who found that project-based learning can contribute to the development of practical competencies in engineering education.

In the knowledge domain, the achievement in both courses remained within the high to very high categories. This finding suggests that project activities were not limited to practical work but also provided opportunities for students to connect theoretical concepts with their application. The higher achievement in the Electric Motor Control Practicum may be related to the stronger integration between conceptual understanding and direct practical activities in the course. However, this difference should be interpreted cautiously because the knowledge scores were obtained from the final examination and may also have been influenced by factors beyond the PjBL implementation.

Overall, the achievement of the CLOs reached the high category in the two courses. The findings suggest that PjBL can support the implementation of OBE by integrating knowledge, practical skills, and attitudes within a single learning process. Rather than assessing learning solely through academic achievement, the use of project activities allows students to demonstrate how they apply knowledge, perform technical tasks, and behave during the learning process. This is consistent with the core principle of OBE, which emphasizes measurable learning outcomes and competency achievement.

Nevertheless, the findings should be interpreted as evidence of CLO achievement after PjBL implementation, rather than as definitive evidence that PjBL alone caused the observed outcomes. Since this study employed a descriptive evaluative design without a comparison group or pre-intervention measurement, the effectiveness of PjBL is better understood in terms of its contribution to achieving the targeted CLOs. Future studies could strengthen the evidence by using a quasi-experimental design, comparison groups, or longitudinal measurements to examine changes in student achievement more rigorously.

CONCLUSION

The findings indicate that the implementation of Outcome-Based Education (OBE) through Project-Based Learning (PjBL) supported the achievement of the targeted Course Learning Outcomes (CLOs) in the DC Electrical Circuits and Electric Motor Control Practicum courses. The evaluation covered three learning domains: attitudes, practical skills, and knowledge.

The attitude domain achieved an overall score of 86.40%, indicating a Very High level of achievement. This result suggests that students demonstrated positive learning behaviors throughout the project activities, particularly in terms of discipline, responsibility, teamwork, communication, and compliance with occupational health and safety procedures.

The practical skills domain achieved an overall score of 84.87%, which was categorized as High. The results indicate that students were able to apply their knowledge through project activities, including planning, assembling, operating, testing, and evaluating electrical systems in accordance with the targeted CLOs.

The knowledge domain achieved an overall score of 81.79%, categorized as High. This finding indicates that students demonstrated adequate mastery of the concepts and principles assessed through the final examinations. The results also suggest that project-based activities provided opportunities for students to connect theoretical knowledge with practical applications.

Overall, the mean CLO achievement across the three assessment domains was 84.35%, which falls within the High category. These findings indicate that the implementation of PjBL supported the achievement of CLOs within the OBE framework by integrating knowledge, practical skills, and attitudes into the learning process. Therefore, PjBL can be considered a relevant learning model for supporting OBE implementation in electrical engineering education, particularly in courses that require the integration of theoretical understanding and practical competencies.

RECOMMENDATIONS

Based on the findings of this study, Project-Based Learning (PjBL) can be considered a relevant learning approach for supporting the achievement of Course Learning Outcomes (CLOs) within an Outcome-Based Education (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.

The assessment instruments should also be continuously refined to provide a more comprehensive measurement of CLO achievement across attitudes, practical skills, and knowledge. Future research is recommended to involve larger samples, a wider range of courses, and comparative or experimental designs to provide stronger evidence regarding the contribution of PjBL to CLO achievement and OBE implementation in higher education.

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