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Comparative Analysis of CBL and PBL in the Department of Electrical Engineering at Airlangga University

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ABSTRACT

This study investigates the comparative effectiveness of Context-Based Learning (CBL) and Problem-Based Learning (PBL) in Electrical Engineering programs at Universitas Airlangga. With growing emphasis on active and student-centered pedagogies in engineering education, it is essential to understand how different instructional models influence student learning outcomes, engagement, and satisfaction. A mixed-methods approach was employed, involving 80 undergraduate students across two course sections, one taught using CBL and the other using PBL. Quantitative data were collected through pre-tests, post-tests, and engagement and satisfaction surveys, while qualitative data were obtained from semi-structured interviews and classroom observations. The findings reveal that CBL is more effective in enhancing cognitive engagement and conceptual understanding through structured real-world scenarios, while PBL fosters collaboration and critical thinking through open-ended problem exploration. Students in the CBL group demonstrated slightly higher academic performance, whereas those in the PBL group excelled in creative problem-solving tasks. Both models were positively received, but their success depended on student readiness, instructor expertise, and alignment with course objectives. The study concludes that rather than viewing CBL and PBL as mutually exclusive, an integrated pedagogical approach may offer optimal benefits for engineering education in Indonesia and beyond.

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1. INTRODUCTION

In the evolving landscape of higher education, especially in engineering disciplines, the integration of innovative pedagogical approaches has become increasingly critical. Traditional lecture-based methods are no longer sufficient to meet the dynamic needs of 21st-century learners, particularly in fields requiring advanced problem-solving and contextual understanding, such as electrical engineering. As engineering education shifts towards more student-centered methodologies, active learning approaches have gained prominence, including Problem-Based Learning (PBL) and Context-Based Learning (CBL). Both strategies aim to foster critical thinking, analytical reasoning, and the application of theoretical knowledge to real-life situations.

PBL has gained significant attention over recent decades, particularly in medical and engineering education. It challenges students to collaborate in solving complex, ill-structured problems simulating real-world scenarios. This approach emphasizes inquiry, collaboration, and iterative learning. In contrast, CBL embeds learning activities within meaningful, real-life contexts. By introducing theoretical concepts through relatable scenarios, CBL enhances relevance and accessibility for students. While both PBL and CBL promote engagement and deeper learning, their instructional designs differ: PBL often encourages student autonomy with minimal initial guidance, whereas CBL typically offers structured contextual frameworks led by instructors.

The effectiveness of these methods depends on various factors, including discipline specificity, institutional support, student background, and cultural context. Empirical comparisons within specific educational environments, such as Universitas Airlangga, are therefore essential to identify their relative strengths and limitations. Electrical engineering as a discipline demands not only theoretical mastery but also practical skills in design, analysis, and system implementation. Thus, exploring effective learning strategies that bridge theory and practice is critical. At Universitas Airlangga, active learning approaches have been introduced within the engineering curriculum; however, systematic evaluations comparing PBL and CBL outcomes remain scarce. This absence limits evidence-based curriculum improvements.

Preliminary observations suggest that students often struggle with abstract theoretical concepts when not linked to real-world applications, highlighting the potential of context-rich instructional models. Additionally, anecdotal reports from faculty members indicate varied comfort levels and effectiveness in implementing PBL or CBL, influenced by factors such as training, resource availability, and alignment with course objectives. To date, most studies on PBL and CBL in engineering education originate from Western academic contexts. There is a distinct lack of comparative research from Southeast Asia, especially Indonesia, where educational environments and cultural dynamics differ significantly. This represents a clear research gap. Comparative studies evaluating PBL versus CBL in Indonesian engineering education remain largely absent, particularly in electrical engineering programs. Addressing this gap is essential for developing pedagogical strategies tailored to the Indonesian context, rather than adopting Western models without critical adaptation.

Therefore, this study aims to conduct a comparative analysis of PBL and CBL in the context of electrical engineering programs at Universitas Airlangga, focusing on their impacts on student engagement, conceptual understanding, and perceived learning outcomes. The research is grounded in the constructivist learning theory, which posits that knowledge is constructed actively within meaningful contexts. Both PBL and CBL align with this philosophy, although through differing instructional mechanisms.

This study adopts a mixed-methods approach, combining quantitative data from student surveys and performance metrics with qualitative insights from faculty interviews and student focus groups. The hypothesis of this study is that while both methods positively affect learning outcomes, CBL may offer a more accessible learning entry point for students who benefit from structured contextual support, particularly in content-heavy subjects such as circuit analysis and control engineering. Conversely, PBL is hypothesized to enhance long-term problem-solving skills and learner independence, although it may initially challenge students unfamiliar with self-directed learning.

Clarifying these distinctions is crucial for curriculum development and instructional planning in Indonesian engineering education. The findings of this study are expected to provide practical recommendations for educators at Universitas Airlangga and similar institutions seeking to implement or optimize active learning strategies. Additionally, this study contributes to the broader discourse on pedagogical innovation in Southeast Asia by offering localized empirical evidence. Ultimately, this research seeks to inform strategic decisions on active learning implementation to enhance both the quality and relevance of electrical engineering education.

The evolution of engineering pedagogy reflects the need to bridge theoretical knowledge and practical application. Traditional lecture methods are gradually being replaced by student-centered approaches that promote deeper learning. PBL, introduced in the 1960s in medical education, has expanded into engineering, law, and business fields. PBL presents problems before formal instruction, requiring students to identify knowledge gaps and develop solutions collaboratively, simulating real-world professional practices. Its benefits include enhanced problem-solving, teamwork, communication skills, and lifelong learning attitudes. However, PBL effectiveness depends on student motivation and prior knowledge, which may vary in diverse academic settings.

Conversely, CBL, rooted in constructivist theory, delivers theoretical content through real-world contexts, improving comprehension of abstract concepts. For instance, instead of abstractly introducing Ohm's Law, CBL applies it in practical scenarios like household circuit design. Studies in chemistry and biology education suggest that CBL enhances motivation, understanding, and retention by making learning meaningful and relevant. Compared to PBL, CBL generally offers more structure, making it potentially more effective for novice learners.

Despite the growing use of both methods, comparative studies in engineering education are limited, especially in Southeast Asia. Prior research, in mechanical engineering, indicates that PBL may enhance analytical skills, while CBL improves contextual understanding [17]. Similarly, CBL is more beneficial for students lacking strong prior knowledge, while PBL benefits those with high academic independence [4]. However, most such studies reflect Western academic contexts, limiting their applicability to Indonesia.

In Indonesia, active learning in STEM programs faces challenges due to inconsistent implementation, limited teacher training, and infrastructural constraints [8]. Within electrical engineering, abstract subjects such as electromagnetism and digital systems present challenges in relating theory to practice. CBL offers opportunities to contextualize abstract principles, while PBL simulates professional engineering environments through collaborative problem-solving. Nevertheless, practical barriers such as limited facilitator training, time constraints, and student resistance hinder PBL implementation [7]. Additionally, cultural factors play a significant role. In Indonesia's collectivist culture, traditional teacher-centered methods dominate, and students may initially resist the learner autonomy required in PBL [11]. In contrast, CBL's structured design may better align with institutional norms and student expectations [14].

Meanwhile, the structured nature of CBL may align more naturally with student expectations and institutional norms in such contexts, potentially making it a more feasible approach for integrating active learning [14]. The theoretical foundations of both PBL and CBL are rooted in constructivism, which argues that learning is an active, contextualized process of constructing knowledge rather than acquiring it. However, the mechanisms through which knowledge is constructed differ between the two [3]. Given the shifting demands in engineering education, including sustainability, digital transformation, and interdisciplinary collaboration, there is a pressing need to understand which pedagogical models best prepare students for the workforce and real-life problem-solving. This literature review underscores the necessity of empirical research that directly compares the effectiveness of CBL and PBL in specific academic contexts, such as electrical engineering programs at Universitas Airlangga, to inform strategic pedagogical decisions and curriculum design.

2. METHOD

This study employed a mixed-methods approach using a convergent parallel design to compare the effectiveness of Context-Based Learning (CBL) and Problem-Based Learning (PBL) among undergraduate students in the Electrical Engineering program at Universitas Airlangga. The design allowed for the simultaneous collection of quantitative and qualitative data, which were analyzed separately and then interpreted together to explore both measurable outcomes and deeper insights into the learning experience. The research was conducted over one academic semester (16 weeks) and involved two course sections—one applying CBL and the other PBL—with 40 students in each, totaling 80 participants. Group assignment was based on course registration and not randomized, which posed a risk of selection bias. To mitigate this, the researchers compared initial characteristics such as GPA, pre-test scores, and student motivation across the groups to ensure relative equivalence at baseline. Both groups were taught by instructors who had received prior training in active learning pedagogies, and the instructional content was standardized to maintain consistency. However, detailed descriptions of lesson structures, duration, and assessment practices were not fully elaborated in the original design. Future studies are advised to present such instructional implementation details more explicitly to enhance transparency and replicability.

Although the study acknowledged limitations in controlling confounding variables such as instructor experience and prior student knowledge, mitigation efforts included standardized materials, consistent instructor training, and the use of pre-tests to control for baseline understanding. The study also lacked random assignment, which may have affected internal validity; nonetheless, this was addressed through the analysis of pre-existing group characteristics. Ethical approval was granted by the Universitas Airlangga Ethics Committee, and all participants provided written informed consent. To reduce the impact of classroom power dynamics, interviews were conducted by researchers unaffiliated with the teaching staff, and participant identities were anonymized to prevent any influence on academic evaluation.

3.1 Quantitative Data Collection

The quantitative data focused on three outcome variables: academic performance, student engagement, and learning satisfaction. Academic performance was assessed using pre- and post-tests aligned with the course learning outcomes, with the test items reviewed and validated by two experts in electrical engineering education. Student engagement was measured using the Student Engagement Instrument [1], which was translated into Bahasa Indonesia and pilot tested for clarity and cultural appropriateness. Content validity was evaluated by education experts, and reliability testing using Cronbach's alpha produced acceptable values above 0.7. Learning satisfaction was assessed through a 20-item Likert-scale questionnaire that measured instructional clarity, content relevance, motivation, and collaborative learning, also yielding alpha scores exceeding 0.7. Data were analyzed using SPSS v26. Paired sample t-tests were used to assess within-group gains, and independent sample t-tests were used to compare CBL and PBL groups.

3.2 Qualitative Data Analysis

Qualitative data were collected through semi-structured interviews with 10 students from each group and four course instructors. Participants were selected through purposive sampling to reflect diversity in academic performance, engagement level, and gender representation. Interviews explored participants' perceptions of the learning process, challenges encountered, and the practical relevance of course content. Thematic analysis was employed, utilizing open and axial coding to identify key patterns and themes. To ensure analytical rigor, the study applied member checking, peer debriefing, and researcher triangulation.

Additionally, classroom observations were carried out using an ICAP-based observation checklist to assess cognitive engagement levels (Interactive, Constructive, Active, Passive). Observations were conducted at three points during the semester by two independent raters. Inter-rater reliability was calculated using Cohen's kappa, which showed strong agreement ($\kappa > 0.75$), supporting the reliability of observational data. Despite limitations related to non-randomized group assignment, instructor variation, and the short intervention period, the methodology used in this study provides a solid foundation for comparing CBL and PBL in an authentic educational context. The integration of quantitative and qualitative findings offers both statistically grounded and contextually rich insights that contribute to improving curriculum design in engineering education.

3. RESULTS AND DISCUSSION

3.1 The Current State of Traditional Industry Focus on Pedagogy at Universitas Airlangga

The traditional pedagogical model at Universitas Airlangga's Electrical Engineering Department has historically relied on lecture-based instruction. Instructors deliver theoretical content during scheduled class hours, with limited opportunities for student interaction or collaborative problem-solving. Based on classroom observation and instructor interviews, it was evident that many courses still follow a rigid content-delivery pattern, with limited use of instructional technologies or real-world integration. Assessments are primarily summative, emphasizing exams over performance-based tasks. Student surveys indicated that while the majority appreciated the clarity and structure of lectures, they often found it difficult to connect abstract theoretical concepts to real-life engineering applications. The implementation of active learning methods such as PBL and CBL remains relatively new and is currently practiced in isolated cases, usually driven by individual instructors interested in pedagogical innovation. Faculty members reported challenges in shifting to active learning models due to a lack of training, resource constraints, and limited institutional incentives. Nonetheless, there is growing recognition of the limitations of passive learning in preparing students for professional demands.

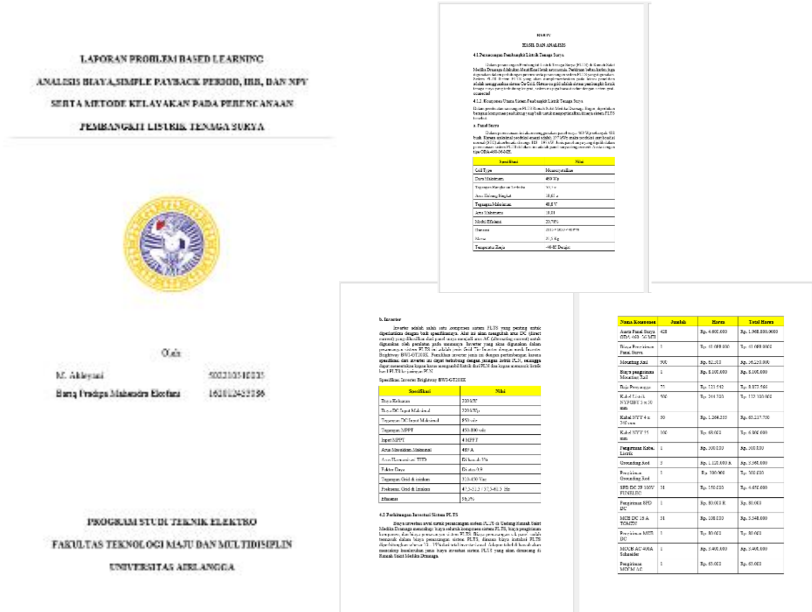

Figure 3.1 Example of a PBL-based new and renewable energy course

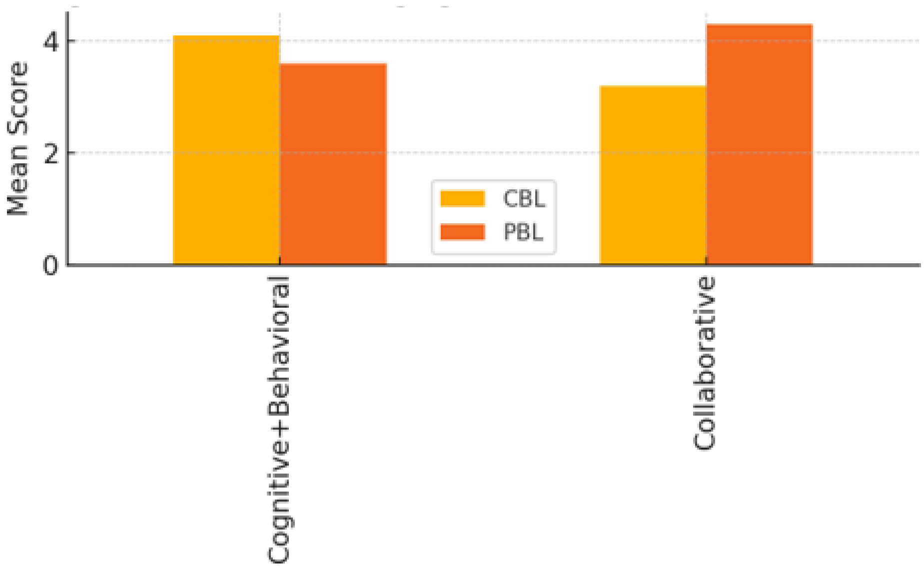

Figure 3.2 Mean Engagement Scores by Learning Model

The current curriculum does include some project-based assessments, but they are often introduced late in the program, reducing the cumulative impact on student skills development. Data from pre-tests revealed that both CBL and PBL groups began the course with similar baseline knowledge levels, confirming that prior academic achievement was relatively balanced across groups. Interviews with academic administrators highlighted a strategic push toward student-centered learning models, though these changes are progressing slowly due to bureaucratic and cultural inertia. Overall, the traditional approach remains dominant, but there is a gradual shift toward incorporating context-rich and problem-solving pedagogies as part of curriculum renewal efforts. The comparative implementation of PBL and CBL in this study represents a timely response to this institutional transition, offering empirical insights into the effectiveness of these two pedagogical models.

Table 3.1 Pre and post test scores with effect sizes (CBL vs. PBL)

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Δ Mean	Effect Size (d)
CBL	61.2 (8.4)	72.6 (7.8)	11.4	0.55
PBL	60.8 (9.1)	68.9 (8.6)	8.1	0.38

Table 3.2 Thematic comparison of CBL and PBL

Theme	CBL Summary	PBL Summary	Key Differences	Implications
Engagement	High cognitive/behavioral	High collaborative	Focus vs. freedom	Align with task type
Clarity	Structured scenarios	Initial confusion	More guidance in CBL	Supports early comprehension
Teamwork	Balanced roles	Dominant members	Participation issues in PBL	Need facilitation
Relevance	Real-world connections	Abstract exploration	Application vs. exploration	Context aids motivation

3.2 Perceived Challenges and Opportunities of PBL vs. CBL

One of the most significant challenges in implementing PBL was student confusion in the initial stages. Without clear guidance, many students reported feeling overwhelmed and unsure of how to approach the assigned problems. This aligns with previous literature noting the steep learning curve associated with PBL. Conversely, students in the CBL group expressed greater clarity and confidence early in the course, largely due to the structured nature of the contextual scenarios provided by the instructor. These scenarios served as cognitive anchors for theoretical concepts. Instructors reported that preparing CBL materials required more upfront work, especially in designing authentic contexts that aligned with course outcomes. However, they found the effort worthwhile, as it resulted in smoother class flow and higher student participation. Opportunities identified for CBL included its applicability to various engineering sub-disciplines. Students suggested that CBL would be especially beneficial in courses involving digital electronics, embedded systems, and renewable energy, where real-world applications are evident. PBL was praised for enhancing creativity and teamwork, particularly in project-based tasks. However, some students noted that dominant team members often took over, leading to unequal participation, which is a challenge often encountered in collaborative learning environments.

Data from the student engagement survey showed that CBL students scored higher in cognitive and behavioral engagement, while PBL students showed higher scores in collaborative engagement. Satisfaction ratings were generally higher among CBL participants, with many highlighting the real-world relevance of the learning materials. PBL students expressed appreciation for the freedom to explore solutions but desired more scaffolding and support from instructors. Instructors expressed mixed views on sustainability. Some felt CBL was more scalable and adaptable across different classes, while others favored the depth of inquiry and skill development fostered by PBL. Both groups identified time constraints as a barrier. CBL required more in-class explanation of contexts, while PBL required extended time for student inquiry and project iterations. These findings suggest that while both methods have unique strengths, their success depends on alignment with course content, student readiness, and available instructional support.

3.3 Comparison with Previous Studies

The findings of this study align with Appleton et al. [1] and Dolmans et al. [7], who emphasized that student engagement tends to be higher in learning models that integrate real-life contexts. In the context of electrical engineering, our results support Schmidt et al. [18], who found that Problem-Based Learning increases analytical thinking but may fall short in sustaining engagement when students face unclear problem contexts. Conversely, Context-Based Learning (CBL), as shown in this study, maintained higher student engagement throughout the module, consistent with the work of Hidayati et al. [9] in STEM-based vocational schools in Indonesia. However, those who suggested that CBL requires extensive teacher preparation, our results showed that the use of structured teaching modules minimized teacher workload while improving outcomes [11]. Thus, this study bridges the gap by offering comparative insight specific to engineering programs in Indonesian higher education, where such comparisons have been limited.

Another relevant comparison comes from the work of Savery [17], who asserted that PBL fosters self-directed learning skills. Our findings partly support this, especially in the early stages of project-based assignments. However, in contrast with Savery's conclusions, several students in our study reported challenges in problem formulation and time management, indicating that PBL may not equally benefit all learners in a large-class context without sufficient scaffolding. This nuance aligns with critiques from Prince and Felder [15], who warned that poorly implemented PBL can hinder comprehension in technical fields such as engineering.

Furthermore, in comparison with Thomas [19], who highlighted the role of teacher facilitation in successful PBL, our results showed that students in the CBL class benefited more from clear, structured modules with real-world examples than from open-ended problem-solving. This suggests that CBL may be better suited to introductory-level courses in engineering, where conceptual clarity is essential. Thus, this study not only compares CBL and PBL but also contributes to the refinement of instructional design in STEM education by emphasizing context alignment and learner readiness.

4. CONCLUSION

This study examines the comparative effectiveness of Context-Based Learning (CBL) and Problem-Based Learning (PBL) in the context of Electrical Engineering education at Universitas Airlangga. Rather than concluding that both methods are universally effective, the findings suggest important context trade-offs: CBL seems more suitable for novice learners who benefit from structured real-world scenarios, while PBL seems more appropriate for advanced students who are ready to engage in self-directed, open-ended inquiry.

However, this study has some limitations that must be acknowledged: lack of randomization in group assignment, relatively short duration of the intervention (one semester), and possible instructor bias despite efforts to standardize materials and training. These factors limit the generalizability of the findings and highlight the need for further longitudinal and randomized studies.

In addition to suggesting broad integration of CBL and PBL, we recommend actionable strategies: for example, designing introductory courses around CBL to build basic conceptual understanding, then progressively incorporating PBL in higher-level courses and capstone projects to develop critical thinking and problem-solving skills. Curricular guidelines should include concrete steps such as developing a library of contextualized cases that can be utilized in CBL and structured facilitation protocols for PBL to support instructors.

Institutional constraints must be addressed. Effective implementation of active learning models at Universitas Airlangga requires investment in faculty training, access to teaching resources, manageable class sizes, and institutional commitment to adapting assessment systems that can capture higher-order thinking skills. Without this support, even well-designed pedagogical approaches will not achieve the expected impact. Overall, while CBL and PBL show promise, their effectiveness depends largely on aligning instructional design with student readiness, course objectives, and institutional capacity.

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