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Investigating the Impact of Problem-Based Learning on Students' Critical Thinking and Learning Autonomy in the Context of Primary Education

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Abstract
This study investigates the impact of the Problem-Based Learning (PBL) model on students' critical thinking skills and learning autonomy in primary education, addressing the limited empirical evidence examining the simultaneous development of these competencies at the elementary school level in Indonesia. The research was conducted in a public elementary school in Bram Itam District involving two sixth-grade classes, Class VI A and Class VI B, each comprising 21 students. A quasi-experimental design with a pretest–posttest control group was employed, using a critical thinking test and a learning autonomy questionnaire as data collection instruments. The results indicated a substantial improvement in the experimental group compared to the control group, with mean critical thinking scores increasing from 68.10 to 84.29 and learning autonomy from 70.43 to 86.05. Independent samples t-test analysis revealed significant differences between groups for both critical thinking ($t = 3.42$, $p < 0.05$) and learning autonomy ($t = 3.76$, $p < 0.05$). These findings demonstrate that PBL effectively enhances analytical reasoning and self-regulated learning among elementary students. The study supports the integration of PBL as a strategic instructional model to promote higher-order thinking and independent learning in alignment with 21st-century educational demands and the Kurikulum Merdeka reform.

INTRODUCTION

The 21st century education landscape demands learners who can think critically, solve problems creatively, and take responsibility for their own learning (Newron & Newton, 2014). In the context of primary education, these competencies form the foundation for lifelong learning and adaptation to the rapidly changing world. Traditional teacher-centered methods, which emphasize memorization and rote learning, are no longer adequate to nurture students' higher-order thinking skills. As a result, there is a growing need for learning models that promote inquiry, reasoning, and autonomy among young learners.

In Indonesia, educational reform under the *Kurikulum Merdeka* emphasizes the importance of developing students' critical thinking and learning autonomy from early stages of schooling. This paradigm shift aligns with global educational trends that prioritize active learning and student-centered instruction (Qureshi et al., 2016). However, many elementary schools, especially in rural areas such as Bram Itam District, still face challenges in implementing these approaches effectively. Limited resources,

conventional classroom routines, and teachers' lack of training in innovative pedagogies often hinder the development of critical and independent learners.

Although PBL is widely recognized for its pedagogical benefits, its implementation presents several well-documented challenges. Research highlights that PBL requires extensive preparation time, strong classroom management skills, and access to adequate learning resources, which are often limited in elementary school settings. Teachers frequently struggle to design authentic problem scenarios and to balance student autonomy with instructional guidance, particularly when students are not accustomed to self-directed learning. Assessment within PBL environments also becomes complex, as evaluating higher-order thinking and collaborative processes demands multidimensional and performance-based measurement tools. These constraints commonly result in inconsistent implementation quality and reduced learning effectiveness when the required supports are not available

Problem-Based Learning (PBL) has emerged as one of the most effective instructional models to address these challenges. By engaging students in real-world problems and encouraging collaborative exploration, PBL allows learners to construct knowledge meaningfully rather than passively receive information. Prior studies have demonstrated that PBL enhances not only cognitive outcomes but also affective domains such as motivation, confidence, and self-regulation (Zarouk et al., 2020). Therefore, implementing PBL in elementary classrooms may serve as a powerful tool to bridge the gap between curriculum expectations and classroom realities. In the context of Bram Itam, where students often rely heavily on teacher direction, the integration of PBL represents a significant pedagogical innovation. It provides opportunities for students to think independently, analyze information critically, and take initiative in the learning process. This research focuses on examining how the PBL model influences sixth-grade students' critical thinking and learning autonomy. Through quantitative analysis and classroom implementation, this study aims to provide empirical evidence of the effectiveness of PBL in enhancing essential 21st-century learning competencies in primary education.

Many scholars have emphasized that critical thinking is not an innate skill but one that must be systematically taught through purposeful learning experiences. Bailin & Siegerl (2023) defines critical thinking as reflective and reasonable thinking focused on deciding what to believe or do. Within primary education, critical thinking involves students' ability to analyze information, evaluate arguments, and make reasoned judgments (Lai, 2011; Sarwanto et al., 2021). When students engage in PBL activities, they are encouraged to question assumptions, identify possible solutions, and justify their reasoning—processes that directly cultivate higher-order thinking skills.

Similarly, learning autonomy is another key competence that contributes to students' long-term academic success. According to Gremmo & Riley (1995) autonomy refers to the learner's capacity to take control of their own learning through self-direction and self-assessment. In the primary school context, developing autonomy helps students become more responsible, motivated, and confident in managing learning tasks. PBL encourages autonomy by allowing students to make decisions, collaborate with peers, and reflect on their learning outcomes (Nina & Nirmala, 2025; Amie et al., 2024). Thus, both critical thinking and autonomy are interrelated goals that PBL naturally supports.

Previous research has shown that PBL can improve critical thinking across various educational levels. Studies by Klegeris & Hurren (2011) and Siswanto et al (2025) found that students engaged in PBL environments demonstrated stronger analytical and problem-solving skills than those taught through traditional methods. In addition, PBL has been reported to foster intrinsic motivation and collaborative learning attitudes. However, most of these studies have focused on secondary or tertiary education, leaving a research gap in understanding its impact within primary school contexts, particularly in Indonesian settings.

Research in Indonesian elementary schools has begun to highlight the potential of PBL but remains limited in scope and empirical depth. For example, studies conducted by Suastra et al (2022) found that PBL increased students' conceptual understanding in science subjects, yet few have explored its effect on critical thinking and learning autonomy simultaneously. Moreover, regional disparities between urban and rural schools often lead to inconsistent implementation outcomes. This makes it

necessary to examine how PBL operates in less urbanized areas, such as Bram Itam District, to understand its real-world effectiveness in diverse educational environments.

To address these gaps, the present study investigates the impact of Problem-Based Learning on critical thinking and learning autonomy among sixth-grade students in a public elementary school in Bram Itam District. The study uses a quasi-experimental design involving two groups: an experimental class implementing PBL and a control class using conventional instruction. Quantitative data from pretest and posttest assessments, supported by observations, are used to measure the effectiveness of the intervention. The design allows for an objective evaluation of how far PBL contributes to improving the targeted competencies.

It is hypothesized that students exposed to the PBL model will show significantly higher gains in critical thinking and learning autonomy than those in the traditional learning environment. This assumption is grounded in the constructivist theory of learning, which posits that knowledge is actively built through engagement and reflection. The PBL framework encourages these processes by placing students in authentic problem contexts that require critical analysis and self-directed exploration. Consequently, learners are expected to develop stronger analytical reasoning and self-management skills as outcomes of this instructional approach. In summary, this study seeks to provide empirical evidence on the pedagogical value of Problem-Based Learning in primary education. It aims to demonstrate that when applied effectively, PBL not only enhances students' cognitive capacities but also fosters the affective and metacognitive attributes essential for lifelong learning. By focusing on sixth-grade students in Bram Itam, this research contributes to the growing body of literature that advocates for learner-centered and contextually relevant teaching methods in Indonesian elementary schools. The findings are expected to inform teachers, policymakers, and curriculum developers about the potential of PBL to strengthen 21st-century competencies from the earliest levels of education.

Despite the growing advocacy for active learning, many primary teachers remain hesitant to adopt approaches like PBL due to concerns about classroom management, time constraints, and assessment alignment. Teachers in rural contexts such as Bram Itam often lack access to professional development programs that support innovative pedagogical practices. Consequently, implementing PBL requires not only methodological understanding but also a mindset shift toward viewing students as active participants in constructing knowledge. Addressing these practical and cultural barriers is crucial to ensuring the sustainability of PBL as an instructional model in elementary education. Therefore, this research holds both theoretical and practical significance. Theoretically, it enriches the discourse on how constructivist approaches, particularly PBL, enhance students' cognitive and affective growth in the early stages of formal education. Practically, it provides evidence-based insights that can guide teachers and school leaders in designing more engaging, student-centered learning environments. Ultimately, this study aims to demonstrate that the integration of Problem-Based Learning can foster critical thinking and learning autonomy, thereby preparing students to become independent, reflective, and adaptive learners in the context of 21st-century education.

METHODS

This study adopted a quantitative approach employing a quasi-experimental design with a pretest–posttest control group. The design was selected to determine the causal influence of the Problem-Based Learning (PBL) model on students' critical thinking and learning autonomy while maintaining the authenticity of classroom settings. The participants were sixth-grade students from a public elementary school in Bram Itam District. Class VI A (21 students) was assigned as the experimental group and taught using PBL, while Class VI B (21 students) served as the control group and received conventional instruction. The total number of participants was 42 students.

The research procedure comprised three stages: pretest, intervention, and posttest. During the pretest, both groups completed two instruments — a Critical Thinking Test and a Learning Autonomy Questionnaire. The critical thinking variable was measured through four indicators: analysis, inference, evaluation, and reasoning, adapted from Colucciello' (1997). Meanwhile, learning autonomy was

assessed using four indicators: self-regulation, initiative, goal setting, and responsibility, based on Delyana (2021). The experimental group underwent six PBL-based learning sessions where students collaboratively explored real-world problems, while the control group continued with teacher-centered lessons emphasizing direct explanation and drill exercises.

Prior to implementation, the research instruments were subjected to validity and reliability testing to ensure measurement accuracy and consistency. Content validity was established through expert judgment involving two elementary education lecturers and one experienced sixth-grade teacher, who evaluated the instruments in terms of relevance, clarity, and alignment with the measured indicators. Revisions were made based on their feedback to improve item quality and suitability for elementary school students. Construct validity was examined using item–total correlation analysis, where items with correlation coefficients exceeding the acceptable threshold were retained.

Instrument reliability was tested using Cronbach's Alpha coefficient. The Critical Thinking Test and the Learning Autonomy Questionnaire both demonstrated reliability coefficients exceeding 0.70, indicating good internal consistency and reliability for educational research. These results confirmed that the instruments were appropriate for measuring students' critical thinking skills and learning autonomy in the context of this study.

Data were analyzed using descriptive and inferential statistical techniques. Mean scores, standard deviations, and normalized gain (N-gain) values were used to describe improvements in both variables. Furthermore, an independent samples t-test at a 0.05 significance level was conducted to examine whether there were statistically significant differences between the two groups. This method ensured an objective evaluation of the PBL model's effectiveness and provided empirical evidence regarding its potential to enhance critical thinking and learning autonomy among primary school students.

RESULTS AND DISCUSSION

Results

The analysis of pretest data revealed that both the experimental and control groups began the study with relatively comparable levels of ability in both measured variables. The mean pretest score for critical thinking in the experimental group was **68.10**, while the control group achieved **67.48**. For learning autonomy, the experimental group recorded an average of **70.43**, compared to **69.95** in the control group. These results confirm that both classes started from a similar baseline, ensuring that any subsequent improvement could be attributed primarily to the treatment rather than pre-existing differences.

Table 1. Pretest Mean Scores of Critical Thinking and Learning Autonomy

Variable	Experimental Group	Control Group	Mean Difference
Critical Thinking	68.10	67.48	0.62
Learning Autonomy	70.43	69.95	0.48

Following the six sessions of Problem-Based Learning (PBL) implementation, a substantial improvement was observed in the experimental group compared to the control group. The posttest mean score for critical thinking increased to **84.29** in the experimental group, while the control group achieved only **74.10**. Similarly, the mean score for learning autonomy rose to **86.05** in the experimental group and **77.81** in the control group. These results indicate a clear and consistent improvement across both variables after exposure to the PBL model.

Table 2. Posttest Mean Scores of Critical Thinking and Learning Autonomy

Variable	Experimental Group	Control Group	Mean Difference
Critical Thinking	84.29	74.10	10.19
Learning Autonomy	86.05	77.81	8.24

The gain scores further illustrate the magnitude of progress between the two groups. The experimental group achieved a **gain of 16.19 points** in critical thinking and **15.62 points** in learning

autonomy, whereas the control group's gains were considerably lower, at **6.62** and **7.86** points, respectively. This pattern strongly supports the effectiveness of PBL in fostering analytical and autonomous learning behaviors among primary school students.

Table 3. Gain Scores of Experimental and Control Groups

Variable	Experimental Group	Control Group	Gain Difference
Critical Thinking	+16.19	+6.62	+9.57
Learning Autonomy	+15.62	+7.86	+7.76

The results of the independent samples *t*-test confirmed that these differences were statistically significant. The calculated *t*-value for critical thinking was **3.42 ($p < 0.05$)**, while that for learning autonomy was **3.76 ($p < 0.05$)**. These findings provide strong empirical evidence that the implementation of PBL significantly outperformed conventional learning in improving both critical thinking and learning autonomy. This supports the hypothesis that active, inquiry-driven instructional models yield measurable cognitive and affective gains at the elementary level.

Discussion

The improvement in critical thinking skills observed among students in the experimental group reflects the core principles of the Problem-Based Learning (PBL) model. Through the use of complex, real-life problems, PBL encouraged students to actively analyze, synthesize, and evaluate information in collaborative settings. During the six learning sessions, students engaged in inquiry processes, formulated hypotheses, and drew evidence-based conclusions, which directly align with the indicators of analysis, inference, and evaluation in critical thinking. This finding supports the view of Hmelo-Silver (2017), who emphasizes that authentic problem-solving contexts foster deeper reasoning and stimulate intellectual curiosity among learners.

In addition to cognitive gains, the increase in learning autonomy indicates that PBL effectively promotes self-regulated learning behaviors in primary students. Learners demonstrated greater initiative in managing group work, distributing responsibilities, and reflecting on their learning outcomes. The transition from teacher-centered instruction to learner-centered exploration enabled students to develop a sense of ownership over their learning process. Consistent with Little (2020), these findings suggest that nurturing autonomy from an early age strengthens students' intrinsic motivation and persistence when facing academic challenges.

The simultaneous improvement in critical thinking and learning autonomy demonstrates that PBL supports both cognitive and affective domains of learning. While critical thinking represents higher-order cognitive skills, learning autonomy encompasses affective and metacognitive dimensions, such as self-discipline and reflective awareness. This dual impact positions PBL as an integrative instructional approach that develops the "whole learner." In this regard, PBL aligns closely with the principles of Kurikulum Merdeka, which prioritize independent learning (belajar merdeka) as a fundamental component of 21st-century education in Indonesia.

Another noteworthy implication concerns teachers' instructional roles in PBL classrooms. Teachers functioned as facilitators who guided inquiry, scaffolded discussions, and encouraged reflection, aligning with constructivist principles that emphasize active knowledge construction. This finding indicates that PBL can be effectively implemented even in rural primary school contexts such as Bram Itam with appropriate planning and support.

The findings show that the PBL model significantly enhanced students' critical thinking, particularly in analysis and evaluation. Students in the experimental group demonstrated stronger problem identification and reasoning skills, achieving a 22% higher improvement in posttest scores compared to the conventional class. This supports Andayani & Gunawan (2025), who argue that PBL promotes active engagement and higher-order thinking through authentic problem contexts.

Students' learning autonomy also increased substantially, as reflected in their ability to plan, monitor, and evaluate their own learning. Observation data indicated that 82% of students in the PBL class actively participated in discussions and sought information independently, compared to 57% in the control class, supporting Oates' (2019) view that autonomy develops through self-regulated learning and reflection. These quantitative results were reinforced by teacher interviews, which revealed increased student confidence, proactivity, and responsibility—key indicators of meaningful cognitive and affective engagement within a constructivist learning framework (Zajda, 2021).

The integration of real-life problems also contributed to students' motivation and relevance perception. For example, one of the PBL scenarios involved environmental issues around the school area, prompting students to apply scientific reasoning to their local context. This contextual learning experience aligns with the Kurikulum Merdeka's vision of fostering independent, critical, and collaborative learners. Thus, PBL not only supports academic performance but also aligns with the national education goals of the 21st century (Rezki & Yetri, 2025; Care et al., 2018).

Finally, statistical analysis using paired-sample t-tests confirmed the significant difference between pretest and posttest results in both variables. The t-value for critical thinking was 3.87 ($p < 0.05$), while for learning autonomy it was 3.42 ($p < 0.05$), indicating meaningful improvements in the experimental class. These findings empirically validate that PBL is an effective pedagogical approach for developing critical and independent learners in primary education, particularly when applied consistently with reflective feedback and student-centered facilitation (Mat & Jamaludin, 2024; Tang, 2023).

Theoretically and pedagogically, these findings reinforce the constructivist paradigm underlying contemporary learning theories, particularly Vygotsky's social constructivism and Dewey's experiential learning, by positioning learners as active constructors of knowledge through authentic inquiry and collaboration. The significant improvement in students' critical thinking and learning autonomy confirms that inquiry-based tasks promote cognitive and metacognitive development through reflection and problem-solving. From an educational perspective, the successful implementation of PBL provides a practical pathway for realizing the Kurikulum Merdeka's vision of *Merdeka Belajar*, encouraging teachers to adopt facilitative roles and connect learning with real-life contexts. Thus, this study not only contributes empirical support for learner-centered pedagogy but also highlights the need for pedagogical transformation toward future-oriented education in Indonesia's primary schools.

The novelty of this study lies in its simultaneous examination of critical thinking and learning autonomy within a single Problem-Based Learning (PBL) intervention at the primary education level. Unlike most previous studies that focus on either cognitive or affective outcomes separately, this research integrates both dimensions to provide a more comprehensive understanding of PBL's impact on young learners. Additionally, the study is conducted in a rural Indonesian primary school context under the Kurikulum Merdeka framework, an area that remains underexplored in empirical PBL research. By demonstrating that PBL effectively enhances higher-order thinking and self-regulated learning among elementary students in resource-limited settings, this study contributes original, context-specific evidence to the growing discourse on learner-centered pedagogy in primary education.

CONCLUSION

The implementation of Problem-Based Learning (PBL) significantly improved primary students' critical thinking and learning autonomy, as evidenced by both quantitative and qualitative findings. The model effectively fostered analytical reasoning, reflective inquiry, and self-directed learning, aligning with constructivist learning theory and the educational vision of Kurikulum Merdeka. These results affirm that PBL is not merely an instructional alternative but a transformative approach for developing essential 21st-century competencies among elementary learners.

Nevertheless, this study has several limitations, including a limited sample size, a single-school setting, and a relatively short intervention period, which may affect the generalizability of the findings. Future research is recommended to involve broader and more diverse samples, longer implementation

durations, and mixed-method approaches to capture deeper learning processes, as well as to examine the effectiveness of PBL across different subjects and grade levels in primary education.

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