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Enhancing Elementary Students' Critical Thinking and Problem-Solving Skills Through the Implementation of Problem-Based Learning at Muhammadiyah 4 Batu Elementary School

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Abstract

In the era of rapidly evolving educational paradigms, critical thinking and problem-solving abilities have become essential competencies for 21st-century learners. However, few studies in the Indonesian elementary context have triangulated data from classroom observations, teacher interviews, and questionnaires to provide empirical evidence of how Problem-Based Learning (PBL) enhances these skills. This study examined the association between PBL and students' behavioral indicators of critical thinking and problem-solving at Muhammadiyah 4 Batu Elementary School. Employing a qualitative descriptive design, the research involved three Grade 5 classes (5A, 5B, 5C; comprising a total of 87 students) and three teachers, spanning six PBL sessions over one semester. Data were collected through classroom observations, teacher and student interviews, and questionnaire surveys to capture the holistic dynamics of PBL in classroom practice. The observation rubric assessed four behavioral indicators—responsibility, confidence, initiative, and discipline—as proxies of critical thinking and problem-solving competence. The results reveal that PBL is associated with higher levels of engagement, curiosity, and analytical reasoning through structured problem scenarios that require collaboration and inquiry. Quantitative findings showed that class 5C achieved the highest responsibility (83.9%), confidence (87.4%), and discipline (86.2%), while class 5A demonstrated the strongest initiative (79.3%). Teachers' interviews confirmed that consistent application of the five PBL stages—problem orientation, inquiry, design, presentation, and reflection—coincided with stronger behavioral outcomes. These findings suggest that PBL supports metacognition, self-regulation, and reflective learning aligned with Indonesia's Kurikulum Merdeka. The study contributes new evidence on elementary-level PBL implementation by integrating validated behavioral rubrics, teacher perspectives, and classroom artifacts within a single descriptive framework.

Keywords: PBL; Critical Thinking; Problem-Solving Skills; Elementary Education; Behavioral Indicators

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INTRODUCTION

In the rapidly evolving landscape of 21st-century education, the ability to think critically and solve problems creatively has become a defining competency for students to thrive in complex and uncertain environments. Traditional learning models that emphasize rote memorization and teacher-centered delivery are

increasingly viewed as inadequate for equipping learners with the analytical, reflective, and decision-making abilities demanded by contemporary society (Lujan & DiCarlo, 2025; Roshid & Haider, 2024; Sajidin, 2026). Education systems across the world, including Indonesia, have therefore shifted toward student-centered pedagogies that cultivate inquiry, reasoning, and collaboration (Farrow et al., 2024; Sari et al., 2024). Within this transformation, Problem-Based Learning (PBL) has emerged as a pedagogical innovation that positions students as active problem solvers rather than passive recipients of knowledge (Bicer et al., 2025; Greenspan et al., 2025).

PBL emphasizes the use of real-world, ill-structured problems as stimuli for learning. Through collaborative investigation, hypothesis generation, data collection, and reflection, students construct their own understanding while developing critical and creative thinking skills (Ghani et al., 2021; Yu & Zin, 2023). This learning model aligns closely with the demands of 21st-century competencies—communication, collaboration, critical thinking, and creativity—often referred to as the "4Cs." In this regard, PBL does not only enhance content mastery but also promotes metacognitive awareness and lifelong learning skills. Students in PBL environments identify authentic problems, formulate hypotheses, collect and analyze information, and evaluate multiple solutions—reflecting higher-order cognitive processes of analysis, evaluation, and creation (Adam, 2015; Costes-Onishi et al., 2025; Pearson & Dubé, 2025; Thornhill-Miller et al., 2023).

Over the last two decades, numerous studies have explored the impact of PBL on cognitive and affective learning outcomes. International research indicates that PBL enhances students' problem-solving strategies, knowledge retention, and engagement in scientific inquiry (Akcay & Benek, 2024; Alashwal & Barham, 2025; Erdem et al., 2025; Nicholus et al., 2023; Tursynkulova et al., 2023). Studies in science education, for instance, show that students involved in PBL demonstrate improved analytical reasoning and communication compared to those in conventional instruction (Akçay, 2009; Alashwal & Barham, 2025; Liu & Pásztor, 2022; Nicholus et al., 2023; Uluçinar, 2023). In addition, previous research suggests that PBL contributes to developing self-confidence, teamwork, and curiosity—dispositions vital for cultivating critical thinkers in a globalized learning context (Koirala, 2025; Pu et al., 2019; Sappaile et al., 2025). However, most of these studies were conducted in secondary or higher education settings and rarely in elementary classrooms. Similarly, within Southeast Asian educational settings, several studies have reported that integrating PBL into science and mathematics curricula increases motivation and academic resilience (Nurhayati et al., 2023; Rohantizani et al., 2025; et al., 2025; Megawati, 2023; Krupa et al., 2025).

In the Indonesian context, the implementation of PBL at the elementary level remains underexplored. While several studies have examined PBL in junior and senior high schools (e.g., Muktar et al., 2023; Suindhia, 2023; Taher, 2022), empirical work at the elementary level—particularly within Muhammadiyah schools—is still limited. Previous Indonesian elementary studies have primarily focused on cognitive achievement or student motivation (e.g., Nurhayati et al., 2023; Krupa et al., 2025), but none have triangulated teacher interviews, validated behavioral rubrics, and fidelity visualization to analyze how PBL fosters behavioral indicators of critical thinking and problem-solving. Consequently, there is limited evidence on how PBL fosters the behavioral dimensions of critical thinking and problem-solving, such as

responsibility, confidence, initiative, and discipline, within authentic classroom contexts. This study addresses that gap by investigating how PBL develops these behavioral indicators in an Indonesian elementary school setting using a triangulated qualitative approach.

This study fills that gap by providing a triangulated qualitative account combining teacher interviews, structured classroom observations, and teacher questionnaires to assess behavioral indicators of critical thinking and problem-solving among Grade 5 students in an Indonesian elementary school. The novelty of this study lies in integrating validated observation rubrics and fidelity mapping to visualize how consistent implementation of PBL stages relates to behavioral outcomes.

The theoretical basis of this study draws on constructivist and socio-constructivist learning theories. Constructivism asserts that knowledge is actively constructed through experience and reflection, rather than passively received from teachers (Le & Nguyen, 2024; D. Wang et al., 2025). Socio-constructivism extends this principle by emphasizing the role of social interaction and collaborative inquiry in shaping understanding (Gaviria Alzate et al., 2025; Walker & Shore, 2015). Within this framework, the four behavioral indicators—responsibility, confidence, initiative, and discipline—represent operational manifestations of self-regulated and critical thinking behaviors. The process involves five interconnected stages: (1) Problem Orientation: Students are introduced to a real-world or contextual problem that stimulates curiosity. (2) Group Inquiry: Students collaborate to identify what they know, what they need to know, and how to find the necessary information. (3) Investigation and Solution Design: Learners engage in data collection, hypothesis testing, and the formulation of possible solutions. (4) Presentation: Groups present their findings to peers and teachers, fostering communication and feedback. (5) Reflection: Students evaluate the process, challenges, and lessons learned, reinforcing metacognition and self-assessment (Ali, 2019; Allchin, 2013; Nurwidodo et al., 2025). Responsibility and discipline align with Zimmerman and Kitsantas' (1997) theory of self-regulated learning, while confidence and initiative reflect autonomy and intrinsic motivation within Deci and Ryan's Self-Determination Theory (2000).

Through these stages, students experience a continuous cycle of inquiry, reasoning, and reflection that progressively strengthens their problem-solving competence. This cyclical model also aligns with *Bloom's Revised Taxonomy*, which places critical thinking at the higher levels of cognitive development—analysis, evaluation, and creation (Adams, 2015; Nanda et al., 2023). Hence, PBL operationalizes these higher-order thinking processes through structured learning experiences that mirror authentic problem contexts.

Preliminary classroom observations and teacher interviews conducted for this study suggest that students engaged in PBL demonstrate enhanced curiosity, logical reasoning, and persistence when tackling complex questions. Teachers reported that PBL fosters responsibility, teamwork, and communication skills, though they also highlighted practical challenges such as limited time and varying student readiness levels. These insights point to the dual nature of PBL: while it holds strong potential for deep learning, it also requires adaptive pedagogy and institutional flexibility.

This research therefore addresses two major gaps: (1) the need for empirical documentation of PBL's implementation in Indonesian elementary contexts, and (2) the need to connect pedagogical practices with measurable cognitive and affective

learning outcomes, particularly critical thinking and problem-solving skills. By combining qualitative and quantitative data, the study offers a comprehensive understanding of how PBL translates into improved student competencies.

The purpose of this study is to analyze the implementation of Problem-Based Learning in fostering critical thinking and problem-solving skills among students of Muhammadiyah 4 Batu Elementary School. Specifically, it aims to: (a) describe the stages of PBL as implemented by teachers, (b) examine students' cognitive and behavioral responses during PBL activities, and (c) identify challenges and enabling factors influencing its success.

The *Kurikulum Merdeka* (Independent Curriculum) in Indonesia emphasizes learner autonomy, contextual relevance, and the integration of real-world issues into classroom learning (Abidin & Malisa, 2023; Fauzan et al., 2023; Priawasana & Subiyantoro, 2024). It encourages teachers to design lessons that promote higher-order thinking and active inquiry—principles that closely parallel those of PBL. Yet, implementing such approaches effectively requires substantial teacher readiness, reflective capacity, and institutional support. In this regard, Muhammadiyah schools provide a meaningful case study because they combine academic excellence with Islamic values and character education, offering a culturally grounded model for PBL adaptation in Indonesian contexts.

The scope of this study is delimited to one Muhammadiyah elementary school in Batu City, East Java, focusing on three fifth-grade classes (5A, 5B, 5C) over one semester. The study aims to (a) describe the implementation stages of PBL by teachers, (b) examine students' cognitive and behavioral responses during PBL activities, and (c) identify challenges and enabling factors influencing its success. By addressing these objectives, the research contributes empirically grounded insights for integrating PBL into Indonesia's Kurikulum Merdeka and supports the realization of *Profil Pelajar Pancasila* through inquiry-driven and reflective learning practices.

METHOD

Research Design

This research employs a qualitative descriptive approach designed to explore and systematically document the implementation of Problem-Based Learning (PBL) and its association with on students' critical thinking and problem-solving abilities in the context of elementary education. The study focused on understanding the real-world application of PBL in classroom settings rather than testing hypotheses or predicting outcomes. A triangulated qualitative design combining interviews, classroom observations, and teacher questionnaires was implemented to ensure convergence of data sources and strengthen the trustworthiness of findings (Miles et al., 2014). Figure 1 presents the overall research design flow, including setting, participants, instruments, procedures, and data analysis stages.

Research Site and Participants

The study was conducted at Muhammadiyah 4 Batu Elementary School, located in Batu City, East Java, Indonesia. This site was purposively chosen because it had actively implemented the Kurikulum Merdeka and adopted inquiry-based innovations in science learning. The participants included three homeroom teachers responsible for science instruction in grades 5A, 5B, and 5C, along with 87 students

from these classes (n_1 = 29, n_2 = 29, n_3 = 29). Teachers were selected as key informants based on their experience with PBL and willingness to participate in interviews and classroom observations. Students were involved as natural participants observed during PBL implementation.

The sampling strategy was purposive and criterion-based, ensuring that selected teachers had prior exposure to PBL through institutional training. The demographic composition of students ranged from 10 to 11 years old, with balanced gender distribution (45% male; 55% female). Given the qualitative descriptive nature, sample adequacy was determined by data saturation and within-case consistency rather than statistical power.

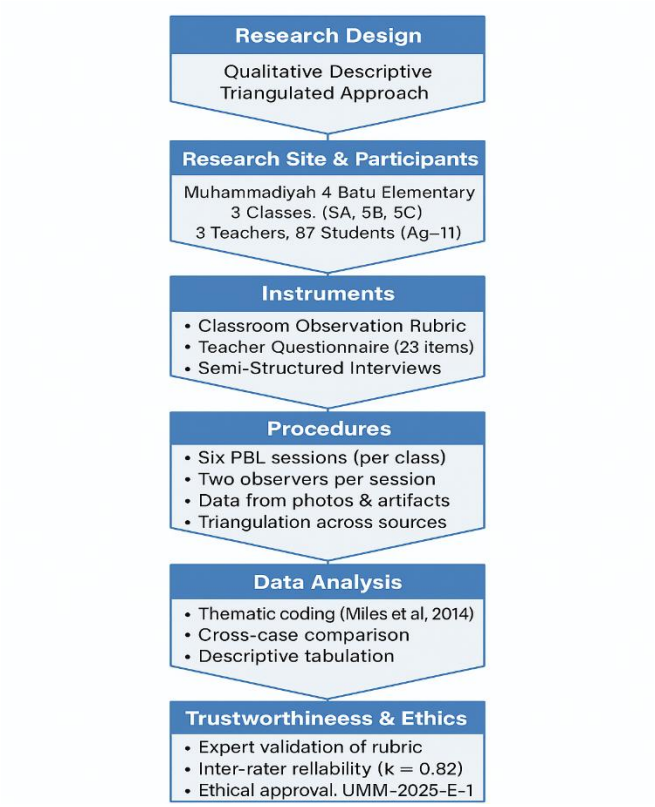

Figure 1. Research design flow illustrating the sequential stages of the qualitative descriptive study, including participants, instruments, procedures, data analysis, and ethical assurance.

Instruments

Three main instruments were employed in this study: teacher interview protocol, classroom observation rubric, and teacher questionnaire. These instruments were validated by two experts in educational methodology and curriculum design to ensure content relevance and clarity.

Teacher Interview Protocol

Semi-structured interviews were conducted to explore teachers' understanding, experiences, and challenges related to PBL. The interview guide consisted of four thematic domains: (a) understanding of PBL concepts, (b) implementation practices, (c) perceptions of student independence and critical thinking, and (d) instructional challenges.

Each interview lasted approximately 45–60 minutes and was audio-recorded with participant consent. Table 1 presents the domains, sample questions, and links to research objectives.

Table 1. Teacher Interview Protocol

Domain	Purpose	Number of Questions	Example Question	Linked Objective
Understanding of PBL	Explore teachers' conceptual grasp of PBL principles, stages, and characteristics	5	"How do you define Problem-Based Learning, and what do you consider its key stages?"	Describe teachers' understanding of PBL
Implementation Practices	Identify how PBL is applied in classroom settings	6	"Can you describe how you guide students through the PBL stages in science learning?"	Describe the stages of PBL as implemented by teachers
Student Independence & Critical Thinking	Examine how teachers perceive changes in student behavior and thinking during PBL	6	"In what ways do you observe your students becoming more responsible or confident when engaging in PBL activities?"	Examine students' cognitive and behavioral responses
Instructional Challenges	Identify barriers and constraints in implementing PBL	6	"What are the main challenges you face when integrating PBL into your teaching schedule?"	Identify challenges and enabling factors

Observation Rubric

Observations were carried out across three classes (5A, 5B, and 5C) over six PBL sessions during the semester. Each observation focused on students' behavioral indicators of critical thinking and problem-solving, specifically: responsibility, confidence, initiative, and discipline.

Table 2 provides the operational definitions and behavioral anchors for these indicators. Each was rated on a 4-point scale (1 = very low, 4 = very high). Scores ≥3.00 were categorized as "High," while scores <3.00 were labeled "Low." Inter-rater agreement between two observers reached $\kappa = 0.82$, indicating strong reliability. Field notes and photographs (de-identified) complemented the rubric-based scoring to ensure contextual richness.' Each class was observed twice monthly, totaling six sessions per class, with two independent observers per session.

Table 2. Observation Rubric for Behavioral Indicators

Indicator	Operational Definition	Behavioral Anchors (Examples)	Rating Scale (1–4)	Cut-score for "High"
Responsibility	Student's ability to manage tasks, complete assignments, and take ownership of group duties	Submits tasks on time; reminds peers of deadlines; follows group plans without teacher reminders	1 = Very Low – 4 = Very High	≥ 3.00
Confidence	Degree of self-assurance during discussions, presentations, and decision-making	Volunteers' answers; presents ideas clearly; defends opinions respectfully	1 = Very Low – 4 = Very High	≥ 3.00
Initiative	Willingness to start tasks, propose solutions, or explore new ideas independently	Suggests new project ideas; seeks additional information beyond teacher guidance	1 = Very Low – 4 = Very High	≥ 3.00
Discipline	Consistency in following rules, staying focused, and collaborating effectively	Stays on task; maintains order in group work; completes projects according to schedule	1 = Very Low – 4 = Very High	≥ 3.00

Note: Scores were assigned by two independent observers; inter-rater reliability κ = 0.82, indicating strong agreement.

Teacher Questionnaire

Teachers' perceptions of PBL were further examined through a 23-item questionnaire covering four domains: understanding, implementation, student independence, and constraints. Table 3 lists all items and their Likert-scale format (1 = strongly disagree to 5 = strongly agree). The reliability of the instrument was acceptable (Cronbach's α = 0.89).

Table 3. Teacher Questionnaire on PBL Implementation

Domain	No. of Items	Sample Items	Scale	Reliability (α)
Understanding of PBL	7	"PBL encourages students to connect classroom knowledge with real-world issues."	1 (Strongly Disagree) – 5 (Strongly Agree)	0.89
Implementation Practice	6	"I have implemented PBL activities at least twice per semester."	Same as above	—
Student Independence	5	"PBL improves students' confidence, discipline, and problem-solving ability."	Same as above	—
Constraints and Readiness	5	"Time management and assessment load are the main barriers to consistent PBL application."	Same as above	—

Overall reliability: Cronbach's α = 0.89 (acceptable internal consistency).

Procedures

The research was conducted across one academic semester (February–June 2025). Each PBL cycle lasted 60 minutes and followed the five stages of PBL: problem orientation, group inquiry, investigation and solution design, presentation, and reflection. Two trained observers independently coded each session using the rubric described in Table 2.

Classroom photos and project artifacts (e.g., posters, models) were collected only from consenting participants and de-identified before analysis. Interview and questionnaire data were transcribed, coded thematically, and triangulated with observation results to strengthen data validity (Miles et al., 2014).

Ethical Considerations

This study received ethical approval from the Postgraduate of Universitas Muhammadiyah Malang Research Ethics Committee. Written informed consent was obtained from school authorities, teachers, and parents/guardians of all participating students. Child assent was also collected verbally prior to each observation. All photos and artifacts were anonymized, and no personally identifying information was stored or published. Data were used solely for academic and research purposes.

RESULTS AND DISCUSSION

The implementation of Problem-Based Learning (PBL) at Muhammadiyah 4 Batu Elementary School revealed a dynamic interplay between pedagogy, student engagement, and teacher facilitation that collectively shaped the development of students' critical thinking and problem-solving abilities. Across the three fifth-grade classes (5A, 5B, 5C), teachers adopted varying degrees of PBL fidelity, resulting in observable differences in student behavior, initiative, and reflective practice. Figure 2 illustrates the fidelity of PBL implementation across the three classes, showing the extent to which each phase—problem orientation, inquiry, design, presentation, and reflection—was consistently applied.

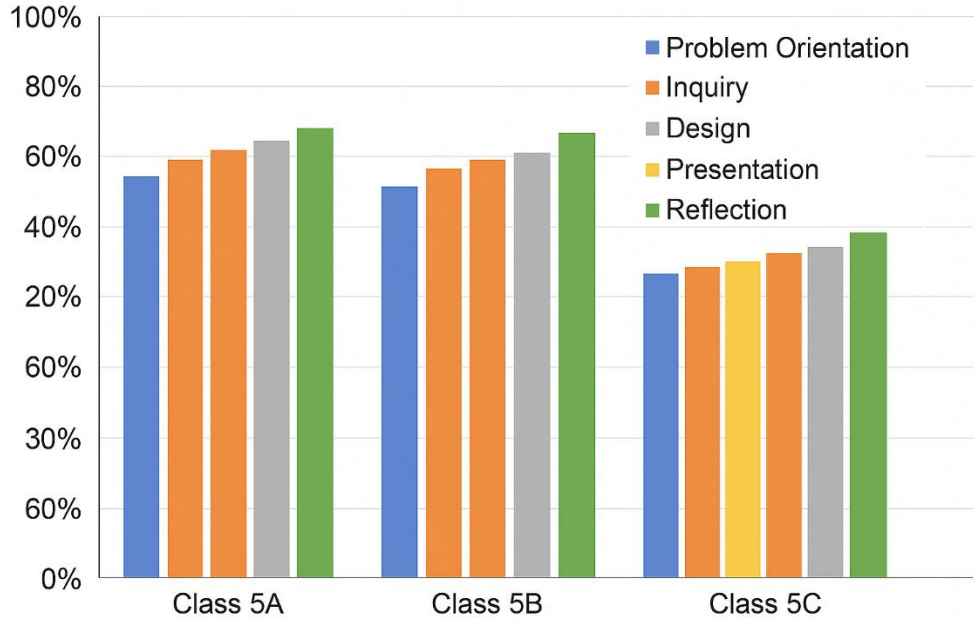

Figure 2. PBL fidelity across classes

Implementation of Problem-Based Learning

Teacher interviews confirmed a consistent understanding of PBL principles across all classes. All teachers demonstrated strong familiarity with PBL definitions, stages, and characteristics, and expressed positive attitudes toward its use. They perceived it as a systematic and enjoyable form of learning that encouraged active student participation and the creation of tangible products. This shared conceptual grasp was evident in statements such as: *"In PBL, students are not only asked to answer questions but to explore and find solutions themselves"* (Teacher 1). Teachers emphasized that PBL integrated knowledge acquisition with authentic experiences, bridging abstract scientific concepts with everyday life. Another teacher reflected, *"When students build their own models or test ideas, they remember the concept longer and understand it better."*

All teachers reported that PBL was implemented multiple times per semester, supported by structured learning modules and documentation of student projects. However, time management and assessment load were cited as persistent challenges, particularly in 5A and 5B. Despite these issues, teachers agreed that PBL increased students' motivation, confidence, and persistence in tackling complex problems.

The classroom implementation typically followed five phases: (1) orientation to the problem, (2) collaborative inquiry, (3) investigation and solution design, (4) presentation, and (5) reflection. During the orientation phase, teachers presented open-ended problems drawn from real-life situations, such as how the respiratory system functions or how waste segregation could reduce pollution. Students then worked in groups to identify what they knew and what they needed to learn. The inquiry phase involved searching for information through textbooks, discussions, and internet sources. Teachers acted as facilitators, asking guiding questions and ensuring all students contributed. In the construction phase, students designed solutions, created models, or conducted experiments, often using simple or recycled materials. Presentations became interactive moments where peers evaluated and commented on one another's work. Finally, reflection sessions allowed both teachers and students to assess what had been learned and how collaboration had influenced understanding.

Field observations showed that this cyclical process fostered curiosity and ownership of learning. Class 5C, whose teacher implemented all five stages rigorously, displayed the highest level of engagement and teamwork. They asked probing questions, compared perspectives, and related findings to daily life. This suggests that higher PBL fidelity was associated with stronger behavioral outcomes—a finding visually summarized in Figure 2.

Development of Critical Thinking and Problem-Solving Skills

The observation data (Tables 2–5) provide quantitative evidence of behavioral transformation. Responsibility, confidence, initiative, and discipline were used as behavioral proxies for critical thinking and problem-solving competence. Class 5C recorded the highest percentage of students demonstrating strong responsibility (83.9%), confidence (87.4%), and discipline (86.2%), indicating that consistent exposure to authentic problem-solving tasks strengthened self-regulation. Meanwhile, class 5A showed the highest initiative (79.3%), suggesting that greater teacher flexibility in open-ended inquiry may have empowered students to take more independent actions.

Tables 4–7 present the summary of student observation results categorized into high and low performance levels. Table 4 presents the distribution of student responsibility levels across the three observed classes.

Table 4. Observation of Students' Responsibility

Category	5A	%	5B	%	5C	%
High	68	78.2	65	75.7	73	83.9
Low	19	21.8	22	25.3	14	16.1

The data reveal that responsibility was strongest in class 5C, where 83.9 % of students demonstrated high levels of task ownership, compared with 78.2 % in 5A and 75.7 % in 5B. Confidence, reflected through presentation performance and peer collaboration, followed a similar trend (Table 5).

Table 5. Observation of Students' Confidence

Category	5A	%	5B	%	5C	%
High	63	72.4	66	75.9	76	87.4
Low	24	27.6	21	24.1	11	12.6

Confidence levels peaked in 5C (87.4 %), indicating that structured project presentation opportunities enhanced students' self-efficacy and willingness to articulate ideas. Initiative, although developing more gradually, displayed varied distribution across classes (Table 6).

Table 6. Observation of Students' Initiative

Category	5A	%	5B	%	5C	%
High	69	79.3	61	70.1	40	46.0
Low	18	20.7	26	29.9	47	54.0

Class 5A recorded the highest initiative (79.3 %), suggesting that flexible facilitation encouraged greater self-starting behavior. Finally, discipline emerged as a consistently strong attribute across all groups (Table 7).

Table 7. Observation of Students' Discipline

Category	5A	%	5B	%	5C	%
High	66	75.9	64	73.6	75	86.2
Low	21	24.1	23	26.4	12	13.8

The results confirm that class 5C consistently achieved the highest levels of responsibility, confidence, and discipline, reflecting closer adherence to the full PBL cycle. Initiative, although generally lower, was strongest in 5A, which offered students more autonomy in project selection.

Students' sense of responsibility appeared in their ability to divide tasks and meet deadlines without direct supervision—a behavioral sign of self-regulated planning (Zimmerman & Kitsantas, 1997). Confidence was visible in improved verbal expression during presentations. For instance, initially reserved students became increasingly vocal after successive PBL cycles, demonstrating growing self-efficacy. Initiative emerged when students proposed new topics or investigative methods,

aligning with Deci and Ryan's (2000) concept of autonomy support. Discipline reflected sustained engagement and time management—traits that integrate cognitive and affective dimensions of learning. These four indicators collectively illustrate how behavioral regulation and cognitive engagement operate simultaneously in effective PBL classrooms.

Students' sense of responsibility was reflected in their ability to divide group tasks and adhere to deadlines without direct supervision. This finding echoes the theoretical framework of self-regulated learning proposed by Zimmerman and Kitsantas (1997) , where responsibility and planning are early indicators of autonomous behavior. Observations recorded that students in class 5C created group schedules and reminded each other about project submissions, displaying intrinsic motivation to achieve shared goals. Teachers corroborated this observation, as one noted, *"They learn to manage themselves. I rarely have to remind them to finish their projects."*

Confidence manifested through verbal expression during group presentations and peer discussions. Students who initially appeared reserved became increasingly vocal in sharing ideas and justifying their reasoning. One teacher described the transformation: *"At the beginning, only a few dared to speak, but after two projects, almost all groups could explain their findings clearly."* This growth aligns with the view that PBL provides psychological safety for students to take intellectual risks—an essential condition for cultivating critical thinking. By presenting their work publicly, students internalized the confidence to evaluate and defend their arguments, a behavior consistent with metacognitive regulation and argumentation theory in constructivist learning.

Initiative, although the lowest-scoring indicator overall, remains a critical outcome that highlights the gradual nature of autonomy development. Some students still relied heavily on teacher prompts before initiating tasks. Nevertheless, evidence from class 5A indicates progress toward self-directed learning. As observed, students occasionally proposed new project topics or suggested alternative methods for solving a given problem. This pattern aligns with Deci and Ryan's Self-Determination Theory (Deci & Ryan, 2000; Manninen et al., 2022; Ryan & Deci, 2000), suggesting that intrinsic motivation arises from autonomy support and opportunities for choice. Teachers who provided space for exploration saw stronger initiative behaviors, reinforcing the importance of balancing guidance with independence in PBL classrooms.

Discipline emerged as a prominent behavioral attribute in all three classes, particularly in class 5C, where 86.2% of students maintained high discipline scores. This was observed through punctual task completion, focus during discussions, and adherence to group roles. Such disciplined engagement supports the notion that critical thinking is not solely cognitive but also behavioral, requiring persistence and sustained attention. Teachers noted that structured project timelines and peer accountability helped students internalize time management and cooperation values. As one teacher stated, *"When students work in teams, they feel responsible not just for their score but for their friends' success too."*

The intersection between these behavioral indicators and cognitive skills reinforces the transformative role of PBL. By engaging students in authentic inquiry and reflection, PBL provides a natural environment for the development of critical thinking dispositions such as curiosity, open-mindedness, and systematic reasoning.

For instance, during problem-solving discussions, students demonstrated logical sequencing—identifying causes, predicting outcomes, and justifying solutions—reflecting analytical and evaluative reasoning. The integration of collaborative reflection further strengthened metacognition, as students verbalized what strategies worked and what could be improved (Dharma et al., 2020; Sinusi et al., 2024; Thompson, 2019).

Teacher Reflections and Challenges

Teacher reflections revealed both optimism and pragmatism regarding PBL implementation. All three teachers recognized PBL's potential to enhance student engagement and cognitive growth. However, they identified four key challenges: (1) limited instructional time; (2) assessment complexity for group and individual outcomes; (3) unequal student readiness; and (4) balancing guidance with autonomy. PBL required extensive preparation, coordination, and feedback cycles, which occasionally disrupted the pacing of other curriculum objectives. Teachers noted that evaluating creativity, teamwork, and process-oriented learning required extended observation and qualitative notes, unlike traditional test scoring.

These reflections align with international literature that links successful PBL to teacher facilitation skills, scaffolding, and reflective assessment (Acar & Tuncdogan, 2019; Gholam, 2019). Teachers recommended reducing content load and allowing deeper, fewer projects to achieve higher quality engagement. Despite the challenges, teachers observed major improvements in collaboration, empathy, and persistence. Students learned to listen, negotiate, and combine perspectives—evidence of socio-constructivist co-construction of knowledge (Amerstorfer & von Münster-Kistner, 2021). Overall, teacher feedback supported the associational interpretation that higher fidelity to the five PBL stages coincided with stronger behavioral indicators of responsibility, confidence, initiative, and discipline.

Another challenge involved balancing guidance and autonomy. Teachers noted that too much intervention reduced student independence, while too little support risked confusion. This aligns with findings from international studies that successful PBL depends heavily on teacher facilitation skills, including scaffolding, questioning, and feedback management. To address these concerns, teachers recommended reducing content coverage to allow deeper engagement with fewer, more meaningful projects—a strategy supported by argument of Acar & Tuncdogan (2019) and Gholam (2019) that depth, not breadth, defines quality in inquiry-based learning.

Despite these limitations, teachers observed notable improvements in student collaboration and resilience. The process of identifying and solving real problems fostered empathy and mutual respect among peers. Students learned to listen, negotiate, and integrate differing perspectives—a reflection of socio-constructivist learning where knowledge is co-constructed through interaction. These social dimensions of learning are integral to developing holistic critical thinkers who can navigate diverse viewpoints and uncertainties (Amerstorfer & Freiin von Münster-Kistner, 2021; Ardill, 2025; Bhardwaj et al., 2025; Evans, 2013; X. Wang et al., 2025).

Interpretation in Broader Educational Context

The findings of this study affirm that PBL is a powerful vehicle for nurturing critical and creative thinking among elementary students. Its alignment with the principles of *Kurikulum Merdeka*—independence, collaboration, and contextual

learning—makes it particularly relevant to current educational reform in Indonesia (Candra & Wahzudik, 2024; Kartika, 2024; Utami et al., 2025). By engaging students in authentic inquiry, PBL promotes both cognitive depth and character development, bridging academic learning with personal growth.

From a theoretical standpoint, the results validate the constructivist principle that knowledge is actively built through experience and reflection, while the socio-constructivist view explains how dialogue and collaboration scaffold understanding (Gaviria Alzate et al., 2025). The structured problem scenarios provided cognitive challenges that stimulated analysis, synthesis, and evaluation—levels of thinking situated at the upper tiers of Bloom's Revised Taxonomy. Simultaneously, peer collaboration and reflection exemplified socio-constructivist mechanisms, enabling students to externalize reasoning and refine understanding through dialogue (Cahusac de Caux & Pretorius, 2024; Ceballos et al., 2026; Zabolotna et al., 2025).

Moreover, the observed behavioral indicators—responsibility, confidence, initiative, and discipline—reflect the interconnection between cognitive and affective domains in learning. Critical thinking is not merely a skill but a disposition that flourishes in environments that encourage autonomy, accountability, and curiosity. The consistent improvement across these domains demonstrates that PBL can operationalize abstract educational ideals into measurable behavioral outcomes (Ghani et al., 2021; Khoiriyah & Husamah, 2018; Yu & Zin, 2023).

Institutionally, these findings call for stronger systemic support: professional development in inquiry facilitation, reflective assessment tools, and scheduling flexibility. Integrating PBL indicators into school evaluation frameworks could help institutionalize deep learning practices. Training programs that emphasize inquiry facilitation, reflective assessment, and time management could enhance teachers' readiness to implement PBL effectively. Furthermore, integrating PBL outcomes into school-level evaluation systems could reinforce its sustainability as a pedagogical innovation (Loyens et al., 2008; Smith et al., 2022; Sukackė et al., 2022).

In sum, the data from Muhammadiyah 4 Batu Elementary School illustrate that Problem-Based Learning provides a holistic framework for advancing 21st-century competencies. It transforms learning from memorization to meaning-making, from compliance to curiosity, and from passive absorption to active inquiry. When implemented with fidelity, PBL not only strengthens critical and problem-solving skills but also instills confidence, discipline, and resilience—qualities essential for lifelong learning. The synergy of cognitive engagement and moral formation seen in this study demonstrates that PBL aligns naturally with Indonesia's vision of *Profil Pelajar Pancasila* (Hidayati et al., 2024; Kholifah et al., 2025; Santoso, 2024) and the broader goals of *Education for Sustainable Development (ESD)*, contributing to the cultivation of thoughtful, independent, and socially responsible learners (Husamah et al., 2022, 2023, 2024, 2025; Rahardjanto et al., 2025).

CONCLUSION

This study examined the implementation of Problem-Based Learning (PBL) in three fifth-grade classes at Muhammadiyah 4 Batu Elementary School and analyzed how it relates to students' behavioral indicators of critical thinking and problem-solving. Findings indicated that consistent and well-structured PBL implementation was associated with higher levels of responsibility, confidence, initiative, and

discipline—behavioral indicators that reflect students' engagement and self-regulation during problem-solving activities. The triangulated data from observations, teacher interviews, and questionnaires demonstrated that PBL not only fostered student participation but also cultivated metacognitive and reflective skills. Classes with higher fidelity to all five PBL stages—problem orientation, inquiry, design, presentation, and reflection—tended to show more balanced growth across behavioral indicators. Teachers' reflections supported these observations, noting that students became more responsible, collaborative, and self-confident as they learned to solve authentic problems and present their ideas publicly. Overall, this study provides contextual evidence that elementary-level PBL can strengthen both academic and behavioral dimensions of learning when implemented with clear structure, reflective dialogue, and authentic problem contexts.

RECOMMENDATION

The findings of this study suggest that sustaining the effectiveness of Problem-Based Learning (PBL) in Indonesian elementary schools requires an integrated effort across teacher, institutional, and policy levels. Teachers should receive continuous professional development in inquiry facilitation, scaffolding, and reflective assessment to strengthen their capacity in managing autonomy-oriented classrooms. Schools are encouraged to embed process-based and reflective evaluation systems that measure not only academic products but also teamwork, creativity, and metacognitive growth. Institutional flexibility in curriculum design, scheduling, and resource provision is essential to accommodate the iterative nature of PBL, while cross-disciplinary collaboration can enrich contextual learning. At the policy level, integrating PBL competencies and reflective assessment models into national teacher training and evaluation frameworks will institutionalize this pedagogy as a sustained culture rather than an experimental method. Future multi-site and longitudinal research is also recommended to validate the observed associations between PBL fidelity and behavioral indicators, ensuring that PBL continues to serve as a transformative approach for nurturing independent, critical, and socially responsible learners aligned with the *Kurikulum Merdeka* and the global goals of Education for Sustainable Development (ESD).

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
R. A. Rohmah	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	
B. Budiono		✓			✓			✓	✓	✓	✓	✓		
H. Husamah	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	

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Authors state no conflict of interest.

Data Availability
Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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