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THE EFFECT OF PROBLEM-BASED LEARNING ON CRITICAL THINKING SKILLS IN ISLAMIC RELIGIOUS EDUCATION: A QUASI-EXPERIMENTAL STUDY IN AN INDONESIAN VOCATIONAL HIGH SCHOOL

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Abstract
This study examined the effect of Problem-Based Learning (PBL) on students' critical thinking skills in Islamic Religious Education (IRE) at a vocational high school in Indonesia. A nonequivalent control group quasi-experimental design was employed with 66 Grade XI students at State Vocational High School 02 Bondowoso, selected through purposive sampling and divided equally into an experimental class (PBL) and a control class (conventional instruction). Data were collected using a 17-item PBL implementation scale, a 16-item critical thinking scale (both on a four-point Likert scale), and pre-test/post-test assessments. Instruments were validated using Pearson Product Moment correlation and confirmed reliable via Cronbach's Alpha ($\alpha > 0.60$). Data were analyzed using an independent sample t-test and simple linear regression with IBM SPSS version 25. The t-test revealed a statistically significant difference between groups, $t(64) = 2.079$, $p = 0.042$, with the experimental group achieving a higher mean score ($M = 56.18$) than the control group ($M = 54.15$). Simple linear regression confirmed a significant predictive model, $F(1, 64) = 9.481$, $p = 0.003$, $R^2 = 0.129$, with a standardized coefficient $\beta = -0.359$. These results indicate that PBL significantly affects students' critical thinking skills in IRE; however, optimal outcomes require improvements in teacher facilitation quality and student readiness for inquiry-based learning.

Keywords: problem-based learning; critical thinking skills; Islamic religious education; quasi-experimental; vocational high school

Introduction

In the context of twenty-first-century education, the capacity for critical thinking has emerged as one of the most essential competencies students must develop to navigate an increasingly complex and rapidly changing global landscape (Wibowo et al., 2025). Conventional pedagogical approaches centered on lecture delivery and rote memorization have proven insufficient for cultivating these higher-order cognitive skills, particularly in secondary and vocational education settings where students must simultaneously acquire vocational competencies and broader intellectual capabilities (Lumingkewas & Kasingku, 2020; Rochyati, 2025). In response to these demands, Problem-Based Learning (PBL) has gained considerable attention as an instructional model capable of bridging the gap between declarative knowledge and practical problem-solving. PBL situates learning within authentic, open-ended problems that require

students to analyze, evaluate, and synthesize information rather than passively receive it (Inayati, 2023; Ihtiari et al., 2023). This active, student-centered process has been consistently associated with improvements in critical thinking, engagement, and contextual understanding across diverse educational settings (A. U. Hidayati et al., 2024; Fitria et al., 2024).

Within the domain of Islamic Religious Education (IRE), the pedagogical challenge is particularly pronounced. IRE encompasses not only the transmission of religious knowledge but also the cultivation of moral reasoning, ethical judgment, and reflective engagement with Islamic values, dimensions that inherently demand higher-order thinking (Kardoyo et al., 2020; Siregar et al., 2025). Constructivist learning theories, including those advanced by Jean Piaget and Lev Vygotsky, underscore that students construct meaningful understanding through active experience and social interaction rather than passive reception (Setyawan & Koeswanti, 2021). In this regard, PBL aligns theoretically and pedagogically with the goals of IRE by encouraging students to engage in value discussions, analyze religious cases, and reflect on moral dilemmas—processes that are integral to developing critical and ethically grounded thinking (Inayati, 2023). Moreover, neuroscience perspectives on cognition further support PBL as an approach that activates higher-order brain functions by engaging students in authentic problem-solving rooted in real-world knowledge (Posman Rambe & Nurwahidah Nurwahidah, 2023). Nevertheless, despite these theoretical alignments, the monotony often associated with conventional IRE instruction continues to limit student engagement and meaningful learning (Hijriah & Yusuf, 2024; Iryanto, 2021).

The empirical literature on PBL has demonstrated its positive influence across multiple educational outcomes. Studies conducted in diverse national contexts including China (Deng et al., 2023), Malaysia (Hua et al., 2023), and Indonesia (Fitrisia & Nurmadiah, 2024) have reported that PBL effectively improves student learning outcomes, fosters independent learning characteristics, and enhances both motivation and critical thinking skills. A meta-analysis by Wijnia et al. (2024) further confirmed that PBL positively affects student motivation, which in turn supports sustained cognitive engagement. Within the Indonesian context, research has shown that PBL increases student learning activity, strengthens problem-solving capacities, and contributes to character development across cognitive, affective, and psychomotor domains (Hidayati & Wagiran, 2020; Basri et al., 2025). In the specific context of IRE, studies indicate that PBL improves students' comprehension of Islamic principles, encourages more active classroom participation, and stimulates critical reflection on religious values (Fazrin et al., 2025; Albaab et al., 2025). However, challenges related to teacher preparedness, time management, resource availability, and unsupportive learning cultures remain significant barriers to effective PBL implementation (Liu & Liu, 2021; Agus Triansyah et al., 2023).

Despite the growing body of literature on PBL, a critical gap remains in the empirical evidence base. The majority of existing studies focus on general academic subjects—most notably mathematics and natural sciences and have been conducted in regular senior high school (SMA) or university settings. Quasi-experimental investigations specifically examining the effect of PBL on critical thinking in IRE within vocational high school (SMK) contexts are notably absent. This gap is educationally significant for two reasons. First, vocational high school students operate within a distinct institutional environment that prioritizes applied and vocational skill development, raising questions about whether PBL generates comparable critical thinking gains in this context. Second, IRE in the vocational curriculum occupies a unique positioni. It must foster moral and reflective competencies within a limited instructional time allocation and alongside competing vocational subject demands. The absence of context-specific empirical evidence limits

the capacity of IRE educators in vocational schools to make evidence-informed pedagogical decisions regarding the adoption of PBL.

This study therefore aims to address this gap by empirically examining the effect of Problem-Based Learning on students' critical thinking skills in Islamic Religious Education at a vocational high school in Indonesia. A nonequivalent control group quasi-experimental design was employed to compare critical thinking outcomes between a PBL-treated experimental class and a control class receiving conventional instruction. The study further seeks to quantify the magnitude of PBL's contribution to critical thinking development through simple linear regression analysis. Two research questions guide this investigation: (1) Are there statistically significant differences in critical thinking skills between students who received PBL instruction and those who received conventional instruction in IRE at a vocational high school? (2) To what extent does the implementation of PBL significantly predict students' critical thinking skills in IRE learning at a vocational high school? The findings are expected to provide empirical grounding for the integration of PBL in IRE instruction at the vocational secondary level and to inform both practitioners and curriculum developers in the Indonesian Islamic education context.

Literature Review

This section reviews the theoretical foundations and empirical evidence underpinning this study. Four interconnected themes are addressed: (1) the theoretical basis of Problem-Based Learning and its alignment with constructivist learning theory; (2) PBL as an instructional model for twenty-first-century competencies; (3) the documented effects of PBL on learning outcomes and character development; and (4) the challenges of conventional learning in Islamic Religious Education and the pedagogical relevance of PBL in this context.

Theoretical foundations of problem-based learning

Problem-Based Learning (PBL) is an instructional approach in which authentic, open-ended problems serve as both the starting point and the vehicle for learning. Rather than presenting knowledge as a finished product to be received, PBL positions students as active constructors of understanding who develop new knowledge by engaging with real-world challenges (Inayati, 2023; Ihtiari et al., 2023). This epistemological orientation is firmly rooted in constructivist learning theory. Jean Piaget's cognitive constructivism holds that learners build new knowledge by assimilating new experiences into existing cognitive schemas, while Lev Vygotsky's sociocultural constructivism emphasizes that higher-order thinking is developed through socially mediated interaction within the zone of proximal development (Setyawan & Koeswanti, 2021). PBL operationalizes both principles: it provides cognitively challenging problems that require schema expansion, while the collaborative group-based format inherent to PBL creates the social scaffolding that Vygotsky identified as essential for intellectual growth.

Neuroscientific perspectives further legitimize PBL as an approach for developing critical thinking. Cognitive neuroscience indicates that sustained engagement with ill-structured problems activates prefrontal cortex functions associated with analysis, planning, and evaluative judgment—the same cognitive processes that underlie critical thinking (Posman Rambe & Nurwahidah Nurwahidah, 2023). This convergence between constructivist theory and cognitive neuroscience provides a robust theoretical rationale for adopting PBL as a deliberate strategy for fostering

higher-order thinking, including in subject areas such as Islamic Religious Education where moral reasoning and reflective judgment are central learning objectives.

Problem-based learning and twenty-first century competencies

The growing international emphasis on twenty-first-century competencies—particularly critical thinking, communication, collaboration, and creativity—has positioned PBL as one of the most advocated instructional approaches in contemporary education reform (Wibowo et al., 2025; Fitria et al., 2024). Unlike traditional direct instruction, PBL is designed to make learning purposeful and student-centered: students assume agency in defining problems, searching for relevant information, and constructing evidence-based solutions (Ihtiari et al., 2023). This process cultivates not only subject-matter understanding but also transferable intellectual skills that are indispensable in modern professional and civic life.

A systematic review by Nicholus et al. (2024) found that while PBL's effectiveness may be moderated by students' initial ability levels and prior knowledge, the approach consistently supports the development of flexible, adaptive understanding - outcomes that align directly with twenty-first-century learning demands. Furthermore, PBL has demonstrated utility as an alternative to conventional instruction for developing open-ended problem-solving and communication skills (Rocha, 2025). These findings collectively position PBL not merely as a pedagogical novelty but as an evidence-supported response to the structural limitations of teacher-centered, lecture-based instruction that continues to dominate many classroom settings (Lumingkewas & Kasingku, 2020; Rochyati, 2025).

Effects of problem-based learning on learning outcomes and character development

Empirical studies conducted across multiple national contexts have documented significant positive effects of PBL on both cognitive learning outcomes and affective development. In vocational education settings specifically, Hidayati and Wagiran (2020) demonstrated that PBL implementation led to measurable improvements in problem-solving skills among Indonesian vocational high school students, outperforming conventional instructional methods. More broadly, Basri et al. (2025) confirmed that PBL yields gains across cognitive, affective, and psychomotor learning domains when implemented with a character-value orientation, making it particularly well-suited for holistic educational objectives.

Beyond cognitive outcomes, the character-forming potential of PBL has been documented in the social sciences and religious education literature. Isnaeni et al. (2023) found that PBL in social studies enabled students to build moral reasoning capacities by confronting and navigating complex ethical problems, a process directly analogous to the reflective moral engagement expected in Islamic Religious Education. Kardoyo et al. (2020) further established that PBL, when integrated with character-based literacy approaches, enhances the overall quality of learning by simultaneously developing subject mastery and civic virtue. The motivational dimension of PBL also contributes to its effectiveness: Wijnia et al.'s (2024) meta-analysis of 46 studies confirmed that PBL positively influences student motivation, with effects observed across problem-based, project-based, and case-based formats. Sustained motivation is not merely an affective by-product; it functions as a prerequisite for the deep cognitive engagement that critical thinking development requires (Munawaroh et al., 2022).

Conventional learning constraints and the relevance of pbl in islamic religious education

Islamic Religious Education occupies a pedagogically complex position within the Indonesian secondary curriculum. Its objectives extend beyond knowledge transmission to encompass the development of moral character, spiritual reflection, and ethical reasoning - competencies that are poorly served by the passive, lecture-dominated instruction that remains prevalent in many IRE classrooms (Kardoyo et al., 2020; Siregar et al., 2025). Teacher-centered approaches not only suppress student participation and intrinsic motivation but also fail to engage the higher-order thinking processes - analysis, synthesis, and evaluative judgment that are central to the IRE curriculum's deeper aims (Lumingkewas & Kasingku, 2020; Rochyati, 2025).

In this context, several recent studies have examined PBL as a corrective intervention in IRE settings. Fazrin et al. (2025) found that PBL functioned as an effective strategy for strengthening critical thinking within IRE, simultaneously encouraging greater student participation and deepening engagement with Islamic principles. Fitrisia and Nurmadiah (2024) reported significant improvements in both critical thinking skills and learning interest among IRE students following PBL implementation, demonstrating that the approach can generate affective as well as cognitive gains. At the institutional level, Albaab et al. (2025) conducted a systematic review of PBL implementation in IRE under the Indonesian Merdeka Belajar curriculum framework, concluding that PBL is theoretically and practically compatible with the curriculum's emphasis on student agency and reflective learning.

Nevertheless, the literature is also candid about the conditions required for PBL to succeed. Liu and Liu (2021) identified an unsupportive learning culture and teachers' tendency to default to conventional methods as primary obstacles to effective PBL implementation, while Triansyah et al. (2023) emphasized that teachers must receive adequate professional development and material support to facilitate PBL effectively. These implementation conditions are especially relevant in the vocational high school context, where instructional time is constrained and teachers may have limited experience with facilitative, inquiry-based pedagogy. Accordingly, the effectiveness of PBL in IRE cannot be assumed from theoretical alignment alone; it requires context-specific empirical investigation to establish whether the approach yields the expected critical thinking gains under vocational school conditions.

Methodology

This section describes the research design, study site and participants, data collection instruments, and data analysis procedures employed in this study. A quantitative approach was adopted to test the hypothesized causal relationship between Problem-Based Learning and students' critical thinking skills. The following subsections elaborate each methodological component in sequence.

Research design and approach of the study

This study employed a quantitative approach using a Nonequivalent Control Group Quasi-Experimental design. This design is appropriate when random assignment of participants to conditions is not feasible due to administrative or institutional constraints, yet the researcher seeks to draw causal inferences by comparing pre-test and post-test outcomes across an experimental

group and a control group (Creswell & Creswell, 2018). Both groups were administered pre-tests prior to the intervention and post-tests following its completion, enabling the measurement of change attributable to the treatment while controlling for pre-existing differences in group performance.

The experimental group received Islamic Religious Education instruction delivered through the Problem-Based Learning model, while the control group received instruction through the conventional method predominantly used in the school—namely, teacher-centered lecture-based delivery. The research design is represented schematically in Table 1.

Table 1. *Quasi-experimental research design*

Group	Pre-test	Treatment	Post-test
Experimental	O_1	X	O_2
Control	O_1	—	O_2

Note. O_1 = pre-test of critical thinking skills; X = PBL treatment; O_2 = post-test of critical thinking skills; — = no treatment (conventional instruction).

Research site and participants

This study was conducted at State Vocational High School 02 Bondowoso (SMKN 2 Bondowoso), East Java, Indonesia, during the 2025/2026 academic year. The school was selected on the basis of institutional accessibility and the presence of intact class groups suitable for quasi-experimental implementation. The target population comprised 195 students enrolled in Grade XI across all study programs.

Participants were selected using purposive sampling, a non-probability technique in which samples are chosen based on specific criteria relevant to the research objectives (Creswell & Creswell, 2018). Three existing intact classes were selected: Class XI C was assigned as the experimental group, while Classes XI A1 and XI A2 were combined to form the control group. This assignment was based on academic schedule compatibility and teacher allocation, rather than random assignment—a condition inherent to the quasi-experimental design. The total sample comprised 66 students (33 per group), as summarized in Table 2.

Table 2. Sample composition

Class	Group	Number of Students	Gender
XI C	Experimental	33	Mixed
XI A1 & A2	Control	33	Mixed
Total		66	

Data collection and analysis

Data were collected using two instruments: a self-report questionnaire and a pre-test/post-test assessment. The questionnaire comprised two scales: a 17-item scale measuring the quality of PBL implementation (Variable X) and 16-item scale measuring students' critical thinking skills (Variable Y). All items used a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). The pre-test was administered prior to the intervention to establish baseline critical thinking levels, while the post-test was administered following the completion of the instructional treatment to measure learning gains. A summary of the instruments is presented in Table 3.

Table 3. *Research Instrument Summary*

Variable	Instrument	Items	Purpose
PBL (X)	Questionnaire (Likert 1–4)	17 items	Measure PBL implementation quality
Critical Thinking (Y)	Questionnaire (Likert 1–4)	16 items	Measure critical thinking skills
Both variables	Pre-test & Post-test	Essay/structured	Measure before/after learning outcomes

Prior to data collection, both instruments were subjected to expert validation by specialists in learning methodology and educational statistics to ensure content validity. Item-level validity was then assessed using Pearson Product Moment correlation at a significance level of $\alpha = 0.05$. An item was declared valid if its calculated r value exceeded the critical r table value (r table = 0.242 for n = 66). Reliability was assessed using Cronbach's Alpha coefficient; instruments with $\alpha > 0.60$ were considered reliable (Creswell & Creswell, 2018). The results of these validation procedures are reported in the Findings section.

Data analysis procedures

Data analysis was conducted in two sequential stages using IBM SPSS version 25. The first stage involved prerequisite assumption tests to verify that the data met the statistical conditions required for parametric analysis. The second stage involved inferential statistical tests to address the research questions. Table 4 summarizes the full sequence of analytical procedures.

Table 4. *Data analysis procedures*

No.	Analysis Type	Test Used	Purpose
1	Instrument Validity	Pearson Product Moment (r)	Ensure items measure intended construct
2	Instrument Reliability	Cronbach's Alpha ($\alpha > 0.60$)	Ensure internal consistency

3	Normality (Prerequisite)	Kolmogorov-Smirnov	Confirm normal distribution of residuals
4	Linearity (Prerequisite)	ANOVA Linearity Test	Confirm linear relationship between X and Y
5	Hypothesis Testing	Independent Sample t-test	Compare means between experimental and control groups
6	Effect Estimation	Simple Linear Regression	Quantify PBL's contribution to critical thinking

In the first stage, a one-sample Kolmogorov-Smirnov normality test was conducted to confirm that residuals were normally distributed ($p > 0.05$). A linearity test was subsequently performed via ANOVA to verify that the relationship between variables X and Y was linear (Deviation from Linearity $p > 0.05$), a prerequisite for simple linear regression analysis. In the second stage, an independent sample t-test was used to examine whether statistically significant differences in critical thinking scores existed between the experimental and control groups, thereby addressing the first research question. Simple linear regression analysis was then applied to quantify the proportion of variance in critical thinking skills (Variable Y) explained by PBL implementation quality (Variable X), thereby addressing the second research question. The significance threshold for all inferential tests was set at $\alpha = 0.05$.

Finding

This section presents the results of instrument validation tests, prerequisite assumption tests, and inferential statistical analyses conducted to address the research questions.

Instrument validity and reliability

Item-level validity was assessed using Pearson Product Moment correlation at a significance threshold of $\alpha = 0.05$. An item was declared valid if the calculated r value exceeded the critical r table value of 0.242 (df = 64, two-tailed). As presented in Table 1, all 17 items of the PBL scale (Variable X) returned r calculated values greater than 0.242, and all items were therefore declared valid. Similarly, all 16 items of the critical thinking scale (Variable Y) in Table 2 met the validity criterion.

Table 1. *Validity test results - Variable X (PBL implementation, 17 items)*

Item	r calculated	r table	Description
1	0.395	0.242	Valid
2	0.311	0.242	Valid
3	0.357	0.242	Valid
4	0.321	0.242	Valid
5	0.397	0.242	Valid

6	0.417	0.242	Valid
7	0.509	0.242	Valid
8	0.474	0.242	Valid
9	0.419	0.242	Valid
10	0.334	0.242	Valid
11	0.268	0.242	Valid
12	0.427	0.242	Valid
13	0.398	0.242	Valid
14	0.321	0.242	Valid
15	0.248	0.242	Valid
16	0.355	0.242	Valid
17	0.544	0.242	Valid

Table 2. *Validity test results - Variable Y (Critical thinking, 16 items)*

Item	r calculated	r table	Description
1	0.362	0.242	Valid
2	0.333	0.242	Valid
3	0.268	0.242	Valid
4	0.411	0.242	Valid
5	0.427	0.242	Valid
6	0.422	0.242	Valid
7	0.558	0.242	Valid
8	0.381	0.242	Valid
9	0.468	0.242	Valid
10	0.398	0.242	Valid
11	0.460	0.242	Valid
12	0.456	0.242	Valid
13	0.339	0.242	Valid
14	0.314	0.242	Valid
15	0.401	0.242	Valid
16	0.430	0.242	Valid

Instrument reliability was assessed using Cronbach's Alpha. Both instruments exceeded the minimum acceptable threshold of $\alpha > 0.60$, confirming adequate internal consistency for research purposes (Table 3).

Table 3. *Reliability test results*

Variable	Cronbach's Alpha	Items	Description
PBL (Variable X)	0.623	17	Reliable
Critical Thinking (Variable Y)	0.649	16	Reliable

Prerequisite tests

Prior to inferential analysis, two prerequisite assumption tests were conducted: a normality test and a linearity test. The one-sample Kolmogorov-Smirnov test was applied to the unstandardized residuals of the regression model. As shown in Table 4, the Asymp. Sig. (2-tailed) value of 0.200 exceeded the significance threshold of 0.05, indicating that the residuals were normally distributed and that the normality assumption was satisfied.

Table 4. *Normality test results (One-Sample Kolmogorov-Smirnov)*

Statistic	Value	Decision
N	66	—
Kolmogorov-Smirnov Statistic	0.065	—
Asymp. Sig. (2-tailed)	0.200	Normal ($p > 0.05$)

The linearity test was conducted using the ANOVA table to examine whether the relationship between Variable X and Variable Y was linear. As presented in Table 5, the Linearity row yielded a significance value of 0.003, which is less than 0.05, confirming a statistically significant linear relationship between the two variables. Crucially, the Deviation from Linearity row returned a significance value of 0.479, which is greater than 0.05, indicating that the relationship does not deviate significantly from linearity. Both conditions together confirm that the linearity assumption was satisfied and that simple linear regression analysis was appropriate.

Table 5. *Linearity test results (ANOVA table)*

Source	SS	df	MS	F	Sig.
(Combined)	341.668	15	22.778	1.553	0.123
Linearity	138.731	1	138.731	9.457	**0.003**
Deviation from Linearity	202.938	14	14.496	0.988	**0.479**
Within Groups	733.498	50	14.670	—	—
Total	1075.167	65	—	—	—

Independent Sample t-Test

To address the first research question, an independent sample t-test was conducted to determine whether statistically significant differences existed between the critical thinking scores of the experimental and control groups. The results are presented in Table 6.

Table 6. *Independent Sample t-Test results*

Group	N	Mean	SD	t	Sig. (2-tailed)
Experimental	33	56.18	3.964	2.079	**0.042**
Control	33	54.15	3.970	—	—

The experimental group (PBL) returned a higher mean critical thinking score (M = 56.18, SD = 3.964) than the control group (conventional instruction; M = 54.15, SD = 3.970). The independent sample t-test yielded t(64) = 2.079, Sig. (2-tailed) = 0.042, which is less than the significance threshold of 0.05. The null hypothesis (H_0) was therefore rejected, and the alternative hypothesis (H_a) was accepted: there is a statistically significant difference in critical thinking skills between students who received PBL instruction and those who received conventional instruction in Islamic Religious Education.

Simple linear regression analysis

To address the second research question, simple linear regression analysis was conducted to quantify the extent to which PBL implementation quality (Variable X) predicted critical thinking skills (Variable Y) across the full sample. The model summary and coefficient results are presented in Tables 7 and 8.

Table 7. *Regression model summary*

Model	R	R^2	Adj. R^2	F	Sig.
PBL → Critical Thinking	0.359	0.129	0.115	9.481	**0.003**

Table 8. *Regression Coefficients*

Predictor	B	Std. Error	β (Beta)	t	Sig.
(Constant)	78.022	7.438	—	10.490	0.000
PBL (X)	**-0.386**	0.125	**-0.359**	-3.079	**0.003**

The regression model was statistically significant, F(1, 64) = 9.481, p = 0.003, confirming that PBL implementation quality was a significant predictor of critical thinking skills. The coefficient of determination R^2 = 0.129 indicates that 12.9% of the variance in critical thinking scores was

explained by PBL implementation quality, while the remaining 87.1% was attributable to other variables not included in this model.

The unstandardized regression coefficient B = -0.386 (SE = 0.125) and the standardized coefficient β = -0.359 indicate a statistically significant negative relationship between PBL implementation quality scores and critical thinking scores within the full sample (t = -3.079, p = 0.003). This negative direction warrants careful interpretation. Variable X in this regression was the self-reported PBL implementation quality score aggregated across all 66 participants, not a binary group indicator. The negative coefficient therefore reflects a within-sample pattern: among all participants, students who rated PBL implementation quality higher did not necessarily score higher on the critical thinking measure. This finding is consistent with the independent t-test result, which confirms that the experimental group as a whole outperformed the control group—yet it also indicates that individual variation in perceived PBL quality did not translate directly into proportional gains in critical thinking. This pattern suggests that the relationship between PBL implementation and critical thinking development is not linear at the individual level and is likely moderated by factors such as task familiarity, teacher facilitation quality, student motivation, and prior knowledge (Ummat et al., 2024). The regression equation derived from this analysis is: $\hat{Y} = 78.022 - 0.386X$.

Discussion

The findings of this study generate three analytically distinct but interrelated claims: (1) PBL produces significantly higher critical thinking outcomes than conventional instruction at the group level; (2) the magnitude of PBL's individual-level predictive contribution to critical thinking is modest; and (3) the negative regression coefficient reveals a nuanced within-sample pattern between perceived PBL quality and measured critical thinking performance. Each of these claims is examined below in relation to established theoretical frameworks and prior empirical evidence.

PBL and critical thinking: evidence through a constructivist lens

The independent sample t-test result—t(64) = 2.079, p = 0.042—confirms that students in the PBL class achieved significantly higher critical thinking scores (M = 56.18) than those in the conventional class (M = 54.15). This finding is theoretically grounded in the constructivist paradigm established by Jean Piaget and Lev Vygotsky. Piaget's theory of cognitive constructivism posits that meaningful learning occurs through the process of assimilation and accommodation, whereby learners integrate new information into existing cognitive schemas or restructure those schemas when confronted with cognitive dissonance (Setyawan & Koeswanti, 2021). PBL deliberately induces this disequilibrium by presenting students with authentic, ill-structured problems that resist resolution through surface-level recall. Students are therefore compelled to actively reorganize their knowledge structures—a process that directly cultivates the analytical and evaluative dimensions of critical thinking.

Vygotsky's sociocultural theory extends this argument by foregrounding the role of social interaction and collaborative discourse in cognitive development (Inayati, 2023). The zone of proximal development (ZPD), the gap between what a learner can accomplish independently and what can be achieved through guided interaction—is systematically activated in PBL environments through peer discussion, group problem analysis, and teacher facilitation. When students in the IRE classroom discuss real moral dilemmas or analyze Islamic principles through the lens of

contemporary social problems, they engage in the kind of intersubjective negotiation of meaning that Vygotsky identified as the engine of higher cognitive development. The significantly higher critical thinking scores in the experimental group thus reflect not merely exposure to PBL as a technique, but the activation of deeper cognitive processes through socially structured inquiry, a finding consistent with empirical work by Selirowangi et al. (2024), Suryadi et al. (2025), and Fazrin et al. (2025) in comparable Islamic education contexts.

PBL in Islamic religious education: alignment with higher-order thinking objectives

The relevance of PBL for IRE extends beyond generic critical thinking development and connects directly to the disciplinary demands of Islamic education itself. IRE in the Indonesian curriculum is not reducible to the transmission of religious knowledge; its objectives encompass the cultivation of moral reasoning, ethical judgment, and reflective engagement with Islamic values—cognitive processes that occupy the higher rungs of Bloom's Revised Taxonomy, specifically analysis, evaluation, and synthesis (Kardoyo et al., 2020; Siregar et al., 2025). Conventional lecture-based instruction, which predominantly targets the knowledge and comprehension levels of the taxonomy, is structurally ill-suited to develop these higher-order competencies. PBL, by contrast, is architecturally aligned with the upper levels of Bloom's taxonomy: students must analyze the parameters of a problem, evaluate competing interpretations, and synthesize a reasoned solution, precisely the cognitive operations that IRE's moral and ethical objectives demand (Azizah, 2022; Iryanto, 2021).

This theoretical alignment is further supported by neuroscientific perspectives on learning. Rambe and Nurwahidah (2023) argue that problem-based approaches stimulate prefrontal cortex activity associated with executive function, working memory, and evaluative judgment—the neurological substrates of critical thinking. Within the IRE context, posing authentic moral problems, such as analyzing contemporary ethical dilemmas through Islamic principles—activates these cognitive systems in ways that passive listening to religious content does not. The finding that PBL-instructed students outperformed conventionally-instructed peers in critical thinking therefore reflects the productive intersection of PBL's problem-centered structure with IRE's inherently reflective pedagogical goals.

Interpreting the modest effect size: the role of contextual moderators

While the group-level superiority of PBL is statistically confirmed, the coefficient of determination $R^2 = 0.129$ indicates that PBL implementation quality as captured by student self-report scores—accounts for only 12.9% of the variance in critical thinking outcomes across the full sample. This modest effect size is theoretically consistent with the broader PBL literature and does not undermine the practical significance of the group difference. Rather, it directs analytical attention toward the constellation of moderating factors that govern PBL's effectiveness at the individual level.

Albert Bandura's Social Cognitive Theory provides a productive framework for interpreting this variance. Bandura (1997) identifies self-efficacy, an individual's belief in their capacity to execute the behaviors required to produce specific outcomes, as a primary determinant of cognitive engagement and persistence. Students with low self-efficacy in problem-solving are likely to disengage from the demanding analytical work that PBL requires, thereby limiting their critical thinking development regardless of the instructional approach employed (Ummat et al., 2024). In

a vocational high school context, where students have been socialized primarily into applied, skills-based learning rather than open-ended inquiry, self-efficacy for academic problem-solving may be particularly variable contributing to the substantial unexplained variance in the regression model. Additionally, Ryan and Deci's Self-Determination Theory (SDT) posits that intrinsic motivation, which is activated when students experience autonomy, competence, and relatedness, is essential for deep cognitive engagement (Wijnia et al., 2024). PBL's effectiveness in promoting critical thinking therefore depends on whether the implementation conditions - teacher facilitation quality, problem authenticity, group dynamics—are sufficient to activate intrinsic rather than merely compliance-driven engagement. The low R^2 value signals that these motivational and contextual conditions varied considerably across individual students in this study.

Interpreting the negative regression coefficient: perception versus performance

The statistically significant negative unstandardized regression coefficient B = -0.386 (β = -0.359, p = 0.003) requires precise interpretation to avoid a fundamental misreading of the data. This coefficient does not indicate that PBL reduces critical thinking skills. The group-level t-test unambiguously demonstrates the opposite: the PBL group outperformed the control group in critical thinking. The negative coefficient instead reflects a within-sample relationship between students' self-reported scores on the PBL implementation quality scale (Variable X) and their critical thinking scores (Variable Y) across all 66 participants.

This pattern is explicable through the concept of desirable difficulties, originally articulated by Bjork (1994) and subsequently elaborated in the cognitive psychology literature. Desirable difficulties are instructional features that appear to impede performance during the learning process—because they demand greater cognitive effort—yet ultimately enhance long-term learning outcomes. PBL, with its open-ended problems and absence of direct instructional guidance, constitutes precisely this kind of desirable difficulty. Students who found PBL implementation challenging and demanding may have rated the experience less positively on the self-report scale, while simultaneously developing stronger critical thinking capacities through the productive struggle the approach induced. Conversely, students who perceived the process as smooth and comfortable may have engaged less deeply with the cognitive challenge. This inverse relationship between perceived ease and cognitive gain is well-documented in the learning sciences literature (Nicholus et al., 2024; Liu & Liu, 2021) and provides a theoretically coherent account of the negative regression coefficient observed in this study. The practical implication is that teachers should not interpret students' initial discomfort with PBL as evidence of its failure; rather, this discomfort may be a signal that productive cognitive work is occurring.

Implications for practice and future research

Taken together, these findings support the integration of PBL into IRE instruction at the vocational secondary level, while simultaneously identifying the conditions that must be addressed to maximize its impact. Barrows and Tamblyn's (1980) foundational model of PBL specifies that the effectiveness of the approach is contingent on the quality of problem design, the competence of the facilitating teacher, and the collaborative dynamics of the student group not on the method itself in isolation. The modest R^2 value in this study suggests that these implementation conditions were not uniformly present, pointing to the need for systematic teacher professional development in PBL facilitation, particularly in contexts—such as Indonesian vocational high schools—where

the approach represents a substantial departure from established pedagogical norms (Triansyah et al., 2023; Efendi et al., 2025).

Future research should incorporate mediating and moderating variables including teacher facilitation quality, student self-efficacy, intrinsic motivation, and prior academic achievement into the analytical model to more fully account for the variance in critical thinking outcomes. Longitudinal designs would also be valuable for assessing whether the critical thinking gains observed following short-term PBL intervention are sustained over time, and whether repeated exposure to PBL across multiple IRE units produces cumulative cognitive benefits. The present study's quasi-experimental design, while appropriate for the institutional context, limits causal inference; randomized controlled trials, where administratively feasible, would strengthen the evidentiary basis for PBL's effectiveness in this context.

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