
THE EFFECT OF PROJECT-BASED LEARNING (PJBL) ON THE CRITICAL THINKING ABILITY OF SCIENCE

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Abstract

This research investigates the effect of the Project-Based Learning (PjBL) model on the critical thinking abilities of third-grade students in the Natural and Social Sciences (IPAS) subject at MI Muhammadiyah Romang Lompoa. The study adopts a quantitative approach using a quasi-experimental method with a nonequivalent control group design. The participants consisted of two classes: an experimental group taught using the PjBL model and a control group receiving conventional instruction, each comprising 20 students. Data were collected through a validated essay-based critical thinking test. Statistical analysis using a t-test was conducted to examine differences between the pre-test and post-test results of both groups. The findings reveal that students' critical thinking abilities significantly improved after the PjBL model was implemented, as seen by the experimental class's higher mean post-test scores than the control group. Therefore, the study concludes that PjBL has a positive and significant impact on enhancing students' critical thinking skills in science-related learning materials.

Keywords

IPAS, Critical thinking skills, Project-Based Learning, Grade III Students.



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INTRODUCTION

The 21st century is marked by rapid developments in technology and information, along with increasingly complex global challenges that require learners to possess advanced thinking abilities. Within basic education, critical thinking (CT) is a core competency that needs to be cultivated from an early stage to enable students to evaluate information, address problems, and make well-reasoned decisions (Alwan, 2022; Aprina et al., 2024; Rahim, 2023). In Indonesia, educational objectives as stipulated in Government Regulation Number 57 of 2021 on National Education Standards emphasize the holistic development of students, including spiritual and religious values, self-regulation, character, intellectual capacity, moral integrity, and essential life skills needed both individually and socially (Barokah, 2025; Desnita et al., 2024; Dewi et al., 2025). To achieve these goals, innovative, participatory, and student-oriented learning strategies are needed (Burhana et al., 2021; Nurfahrani et al., 2023; Waruwu et al., 2025).

Nevertheless, classroom practices in elementary schools remain largely teacher-centered. The lecture method still dominates learning activities, while student activities are limited to listening, taking notes, and memorizing material (Mackatiani & Komo, 2018). This situation hampers the underdevelopment of students' CT abilities, particularly in Natural and Social Sciences (IPAS) subjects that demand analytical reasoning and problem-solving abilities. Learners often show limited participation in exploratory learning, experience difficulty connecting social science concepts to real-world situations, and demonstrate low levels of engagement. Consequently, the learning process becomes repetitive and less effective in fostering students' reasoning skills and curiosity toward surrounding phenomena (Halimah et al., 2023; Nida Winarti et al., 2022; Supriana et al., 2023).

To address these challenges, teachers are expected to implement innovative instructional strategies that encourage active student engagement and strengthen critical thinking abilities. One learning approach that aligns well with the demands of 21st-century education is Project-Based Learning (PjBL). This model positions students as active participants by engaging them directly in the planning, execution, and evaluation of projects centered on real-world problems. Through project-based activities, learners not only acquire conceptual understanding but also apply their knowledge in authentic contexts, thereby promoting meaningful learning experiences (Aziz & Nurachadijat, 2023; Elsa Syafila et al., 2024; Yolanda & Mulyani, 2024). PjBL is characterized by collaborative learning, problem solving through projects, and the production of tangible outcomes

as the culmination of the learning process, commonly referred to as the 4C competencies (Ervina et al., 2025; Lubis et al., 2024; Sholeh et al., 2024).

In elementary social studies education, the implementation of PjBL demonstrates strong potential for enhancing students' CT abilities (Lesman et al., 2023). Science subjects that integrate science and social concepts require logical thinking skills, understanding of cause and effect, and the ability to make decisions based on evidence. Through project activities related to environmental issues or the use of natural resources, students are invited to identify problems, propose hypotheses, design solutions, and evaluate project results (Nurhidayat & Sukri, 2024). The process directly trains the indicators of CT as stated by Ennis, including the ability to provide simple explanations, determine the basis for decision-making, draw conclusions, provide deeper explanations, and determine appropriate strategies and tactics.

However, on-the-ground conditions indicate that the learning process at MI Muhammadiyah Romang Lompoa in Gowa Regency is still dominated by a conventional, teacher-centered approach. Teachers tend to use the lecture method, resulting in low student engagement and underdevelopment of CT skills. This situation results in students being less engaged, limited in expressing ideas, and provided with minimal opportunities to practice creative thinking.

Teachers at MI Muhammadiyah Romang Lompoa still employ conventional learning approaches because limited learning facilities and infrastructure influence their choice of methods. Conventional methods are also considered the most practical amidst the lack of supporting facilities, such as interactive learning media or flexible classrooms for collaborative activities.

To address the continued dominance of conventional learning approaches due to limited facilities and infrastructure, the madrasah needs to establish several strategic policies. One such policy is increasing the provision of learning support facilities, such as technology-based learning media, science demonstration tools, and more flexible classroom layouts to support discussions and group work. These initiatives are intended to establish a learning environment that enables teachers to apply active, student-centered instructional models.

Based on this background, the implementation of the PjBL model is anticipated to be an innovative solution in enhancing students' CT skills. PjBL offers students opportunities to engage in learning through hands-on experience, solve problems collaboratively, and produce concrete products as a form of application of the IPAS concept. Thus, this model not only enhances students' conceptual understanding but also cultivates scientific attitudes, responsibility, and reflective

abilities towards issues in their environment.

Consistent with findings from (Safarni et al., 2025; Taqiya et al., 2024; Umayroh et al., 2024), the implementation of PjBL has proven effective in improving CT at various levels of education. However, empirical studies on the effectiveness of PjBL in learning social studies at the elementary school level, especially in the Madrasah Ibtidaiyah environment, are still relatively limited. Therefore, this study seeks to fill this gap by examining the impact of the PjBL model on the CT skills of third-grade students in science materials at MI Muhammadiyah Romang Lompoa Gowa Regency, South Sulawesi.

Previous research by (Ratno et al., 2024) the application of PjBL led to a significant enhancement of students' CT abilities. The use of this approach encouraged greater student engagement in the learning process and resulted in improved comprehension of the science content being taught. These results further support the view that PjBL is an effective strategy for enhancing the quality of science instruction at the elementary education level.

Research conducted by (Idrus, 2023) demonstrated that the implementation of the PjBL model positively influenced the CT abilities of fifth-grade students in science subjects. Similar findings were also presented by (Permata, 2023) who concluded that PjBL effectively enhanced students' CT skills in fifth-grade science at SD Babussalam Pekanbaru.

The main differences between this study and previous studies lie in the subjects, grade level, research location, and focus of the analysis. The research by Ratno et al. (2024), Idrus (2023), and Permata (2023) focused on the implementation of PjBL for fifth-grade elementary school students in various regions, demonstrating its impact on CT skills. Meanwhile, this study examines the application of PjBL for third-grade students at MIM Romang Lompoa, offering a new perspective on the model's effectiveness at lower grade levels, where CT abilities are still in the early stages of development.

Furthermore, this study was conducted in a madrasah-based educational institution, which has different curriculum characteristics and learning environments than the public elementary schools where previous studies were conducted. Therefore, this study provides a novel contribution by expanding the context of project-based learning (PjBL) implementation to lower grade levels and within the madrasah environment, while also adding to the empirical evidence regarding the effectiveness of PjBL.

The purpose of this study is to find out the extent to which the application of the PjBL model has an effect on improving students' CT skills in science. Theoretically, the findings of this study should contribute to the literature regarding PjBL models' efficacy in primary education. Practically, this study provides recommendations for teachers to implement an innovative and student-centered learning model to enhance the quality of social studies learning and form a generation that thinks critically, creatively, and adaptively to changing times.

METHOD

This research employs a quantitative approach using a quasi-experimental design. Qualitative research methods are approaches based on the positivist paradigm, but are used to examine the natural conditions of objects in contrast to experimental research (Farghaly, 2018). In this method, the researcher acts as the primary instrument, while data sample selection is carried out through purposive and snowball sampling techniques. Data collection utilizes triangulation, or the combination of various sources and methods. Data analysis is conducted inductively and qualitatively, with an emphasis on the meaning contained in the data rather than generalizing the research results (Abdullah et al., 2022). This approach was selected because the study seeks to examine the impact of implementing the PjBL model on students' CT abilities. The design of the pseudo-experiment is used because the researcher cannot fully randomize the research subjects, but uses a class that has been formed beforehand.

Primary data include the results of students' CT ability tests (pre-test and post-test), observation sheets for the PjBL learning process, as well as student response questionnaires on learning and short interviews with class teachers. Secondary data include school curriculum documents, lesson plans, previous academic grades, and class administration records obtained from the school. The research location is at MIM Romang Lompoa (a local elementary school/madrasah). The unit of analysis is third-grade students at MIM Romang Lompoa.

The study employed a non-equivalent control group design involving two groups: an experimental (X) group that received instruction using the PjBL model and a control (C) group that was taught through conventional methods (Suryani et al., 2024). Both groups were administered pre-tests and post-tests to assess improvements in students' CT skills following the intervention. The research design is illustrated as follows:

Table 1. Research Design

Group	Pre-test	Treatment	Post-test
Experiment	O ₁	X	O ₂
Control	O ₃	-	O ₄

Information:

O₁ and O₃ = pre-test score

O₂ and O₄ = post-test score

X = treatment using the PjBL model

The population of this study comprised all third-grade students at MI Muhammadiyah Romang Lompoa, Gowa Regency, South Sulawesi, during the 2024/2025 academic year. Preliminary observations indicated the presence of two parallel classes with relatively similar characteristics in terms of age, academic performance, and learning environment. The sample was determined using purposive sampling by considering the homogeneity of these characteristics and the classes' readiness to participate in the research. Class III A was assigned as the X group, while Class III B served as the control group. Each class comprised 20 students, yielding a total sample of 40 participants.

The independent variable in this research is the PjBL model, while the dependent variable is the CT ability. The research instrument used is a CT ability test developed based on five CT indicators, namely providing elementary clarification, determining the basis for decision-making (basic support), drawing conclusions (inference), providing advanced clarification, and managing strategies and tactics (strategy and tactics). The test instrument is in the form of five description questions that are adjusted to IPAS material on renewable natural resources. These questions were developed to measure students' CT skills comprehensively, ranging from the ability to understand basic concepts to the ability to analyze and evaluate problems. Before being used in the study, the instrument was validated by two primary education experts and piloted on students outside the study sample. The validity test results indicated that all test items met the validity criteria with a calculated *r* value greater than *the r of the table* (0.347). The reliability test yielded a coefficient value of 0.70, which indicates that the instrument is classified as reliable in the high category.

This research is conducted through three stages, namely preparation, implementation, and data analysis. The preparation stage includes initial observation, coordination with the school, determination of experimental and control classes, preparation of learning tools based on the PjBL model, and validation of research instruments. The implementation stage begins with the provision of a pre-test to measure students' initial CT ability. Furthermore, the X class followed learning using

the PjBL model, while the C class used conventional methods in the form of lectures and questions, and answers. After treatment, both groups were administered a post-test to assess improvements in CT ability. The last stage is the collection, processing, and analysis of research data.

The data were collected from the tests administered before and after the intervention. In addition, classroom observations were conducted during the learning process to ensure that the implementation of the PjBL model followed the planned stages, including formulating essential questions, designing projects, developing schedules, monitoring project execution, evaluating project outcomes, and conducting reflection. All test result data is converted to numerical scores to be analyzed using inferential statistics.

Data analysis was conducted through several stages. First, a normality test using the Shapiro–Wilk method was applied to determine whether the data followed a normal distribution, followed by a homogeneity test using Levene’s Test to verify the equality of variances between the experimental and control groups. After these assumptions were satisfied, an N-Gain analysis was performed to measure the extent of improvement in students’ CT skills from the pre-test to the post-test in both groups. Subsequently, hypothesis testing was carried out using an Independent Samples t-test to examine whether a significant difference existed between the CT skills of students in the X and C classes. The decision rule stipulated that if the significance value (Sig. 2-tailed) was less than 0.05, H_0 would be rejected and H_1 accepted, indicating a significant effect of PjBL on students’ CT abilities. All statistical analyses were performed using IBM SPSS version 23 with a significance level of 5% ($\alpha = 0.05$).

FINDINGS AND DISCUSSION

Findings

Table 2. Pre-test results

Class	N	Average (mean)	Standard Deviation	Maximum Score
Experiment	20	56,40	9,25	70
Control	20	57,00	10,10	72

Source: Researcher-Processed Data (2025)

Table 2 presents the pre-test results for both groups. The difference in scores between the two groups is not substantial, as indicated by the similar mean scores, suggesting that students in both groups had relatively equivalent initial abilities.

Table 3. Post-test results

Class	N	Average (mean)	Standard Deviation	Maximum Score
Experiment	20	83,75	8,40	95
Control	20	70,25	7,90	80

Source: Researcher-Processed Data (2025)

Table 3 displays the post-test results, which indicate a clear difference between the two groups, as reflected in the mean and maximum scores achieved by each class. Students in the experimental group tended to obtain scores within higher score ranges, whereas those in the control group were predominantly distributed across lower score intervals. In other words, the final achievement of students in the X class surpassed that of the C class. These findings demonstrate the positive impact of PjBL on the CT ability of third-grade students in science-related materials.

Table 4. t-Test Results

Statistics	Value
Average experiment	83,75
Average control	70,25
Average difference	13,50
Calculated t-value	3,72
DF (Free Degree)	38
Sig. (2-tailed)	0,001

Source: Researcher-Processed Data (2025)

Table 4 presents the results of the t-test, which indicate a change in the mean scores between the X and C groups. The difference in average scores between the two classes was 13.50. Because the significance value (Sig. = 0.001) is less than 0.05, H_0 is rejected, and H_1 is accepted. This finding confirms that the application of the PjBL model has a significant effect on improving the CT skills of third-grade students in science subjects.

Table 5. N-Gain Test Results on Critical Thinking Ability

	Control Class	Experimental Classes
N-Gain	0,21	0,40
Information	Low	Keep

Source: Researcher-Processed Data (2025)

Table 5 shows that improvements in CT skills occurred in both groups, categorized as low and medium. The control class obtained an N-Gain score of 0.21, whereas another class achieved a higher score of 0.40, placing them in different improvement categories. The X group, which received differentiated instruction through the applied treatment, demonstrated a greater increase in CT skills compared to the C group. Based on these findings, it can be concluded that the intervention

had a positive effect on enhancing students' CT abilities.

Table 6. Test Results Per Critical Thinking Ability Indicator

Aspects of Critical Thinking Ability	Control Class		Experimental Group	
	N-Gain	Information	N-Gain	Information
Elementary clarification	0,62	Keep	0,60	Keep
Basic support	0,14	Low	0,46	Keep
Inference	0,13	Low	0,28	Low
Advance certification	0,15	Low	0,58	Keep
Strategy and tactics	0,13	Low	0,22	Low

Source: Researcher-Processed Data (2025)

Table 6 presents the mean N-Gain scores for each aspect of CT ability. In the C group, all aspects were classified within the medium category. The greatest improvement was observed in the elementary clarification aspect, with a score of 0.62, while the lowest gains occurred in the inference and strategy and tactics aspects, each with a score of 0.13. In contrast, the X group showed two aspects within the medium category. The elementary clarification and basic support aspects recorded the highest scores at 0.60 and 0.46, respectively. Meanwhile, the lowest improvement was found in the strategy and tactics aspect with a score of 0.22.

Discussion

The findings of this study indicate that the implementation of the PjBL model has a positive effect on enhancing students' CT skills in science-related learning materials. This is evident from the post-test results, in which the X group that received instruction through the PjBL model achieved a higher mean score of 72.68 compared to the C group, which obtained an average score of 62.68. The score distribution in the experimental group tended to fall within higher achievement intervals (86–100%), whereas most students in the control group were concentrated in lower score ranges (41–65%). These results suggest that the PjBL model is capable of accommodating diverse student learning needs, thereby providing greater opportunities for students to develop their CT abilities more effectively.

The N-Gain analysis revealed a greater improvement in CT skills in the X group (N-Gain = 0.40, medium category) compared to the C group (N-Gain = 0.21, low category). In the experimental group, the elementary clarification and basic support aspects showed relatively high increases, with N-Gain scores of 0.60 and 0.46, respectively. This suggests that students in the X class were more capable of providing simple explanations and offering basic support during the problem-solving process. However, the inference and strategy, and tactics aspects remained relatively low in both groups. These findings indicate that while PjBL is effective in strengthening students' foundational

understanding and CT skills, additional efforts are required to further develop higher-order abilities such as drawing inferences and applying more complex strategies. Therefore, the implementation of the PjBL approach not only enhances academic achievement but also promotes the more comprehensive development of students' CT skills.

This study supports the findings in previous research that stated that the application of learning PjBL can enhance students' CT ability. As explained by Andini & Muhammad (2025) In research on project model learning, this approach offers students opportunities to learn in ways that align more closely with their individual learning styles and abilities, thereby enabling more optimal development of their CT skills. The results of this study indicate that the X group achieved a higher mean post-test score than the C group is in line with the results of the study by Rizki & Noor (2022) which emphasizes that *Project-Based Learning (PjBL)*, which is accompanied by differentiation, can accommodate differences in students' ability levels and directly improve their conceptual understanding in complex subjects, such as social studies learning.

Moreover, the N-Gain analysis revealed a greater improvement in the X group (0.40, medium category) compared to the C group (0.21, low category), further strengthening the evidence that PjBL has an essential role in enhancing students' CT skills. Kusyanto et al. (2022) also reported that learning approaches can effectively develop CT when they provide forms of support that align with students' individual needs. In this regard, the higher N-Gain scores obtained by the experimental group in this study reflect the same pattern.

However, despite significant improvements in the aspects of basic clarification and basic support, the results of this study also reflect the findings of (Sutamrin & Khadijah, 2021), which states that although learning on PjBL can improve students' basic understanding, the ability to develop more complex strategies and make inferences still requires a more intensive approach. The aspects of strategy and tactics, as well as inference, that still showed low results in both groups indicated that developing higher-level CT skills requires more targeted instruction focused on strategic application and the enhancement of inferential abilities.

In addition, this study is in line with the findings of Nahak & Ndapa Lawa (2023) which states that PjBL is effective in promoting students' CT and independent problem-solving abilities. In this study, IPAS instruction implemented within the PjBL framework provides students with opportunities to actively participate in the learning process in ways that align with their interests, learning styles, and individual needs. This approach allows students to build understanding

independently through exploration, collaboration, and discussion, which has been shown to improve their CT abilities. This can be seen from the distribution of values of the experimental group, which was more at high intervals (86–100%) compared to the dominant control group at low intervals (41–65%). These findings also support the (Maharani et al., 2025) which emphasizes that PjBL has a significant positive impact on high-level cognitive learning results, including CT.

In addition to supporting the results of previous research, these findings provide a new perspective on the effectiveness of PjBL in maximizing students' potential, especially in CT on science materials. PjBL has been proven effective in maximizing student potential. Through the PjBL model, students do not merely passively receive information but are directly involved in the process of investigation, problem-solving, planning, and developing learning products (Jalinus et al., 2019). This active involvement encourages students to analyze information, connect concepts, ask in-depth questions, and evaluate various alternative solutions (Wulandari et al., 2025). In the context of science material, PjBL provides ample space for students to experience authentic learning through experiments, observations, and group discussions. This process encourages the development of higher-order thinking skills, such as critical, logical, and systematic reasoning. Consequently, PjBL not only enhances students' understanding of scientific concepts but also supports the holistic development of their potential through activities that require independence, creativity, collaboration, and sound decision-making (Keleman et al., 2021; Sukarma et al., 2024; Song et al., 2025). This model ultimately contributes to a more innovative and effective quality of learning in elementary schools.

Findings on the aspects of elementary clarification and basic support that experienced a significant increase in the experimental group corroborated the study Ramadan & Hindun (2023) which shows that PjBL is able to help students understand fundamental concepts better. However, the findings that the aspects of inference and tactical strategies were still relatively low in both groups showed that the application of more complex learning strategies. Collaborative learning based on in-depth discussions needs to be integrated into PjBL. Thus, the results of this study not only support previous studies but also provide recommendations for further research on the development of students' CT skills on more complex aspects of learning science.

These findings highlight the crucial role of teachers in guiding students to actively apply CT skills through more structured learning approaches and providing additional support for more complex skill areas. This study contributes to the existing body of literature on the impact of PjBL

on CT skills, while emphasizing the importance of fostering students' CT abilities in a holistic manner within science education.

CONCLUSION

The findings indicate that the implementation of the PjBL model has a positive and significant impact on the CT skills of third-grade students in the Natural and Social Sciences (IPAS) subject at MI Muhammadiyah Romang Lompoa. Students who were taught using the PjBL approach demonstrated stronger abilities to analyze information, provide logical reasoning, and draw data-based conclusions than those who experienced conventional instruction. This improvement is reflected in the higher mean post-test and N-Gain scores achieved by the X group, confirming that PjBL is effective in fostering CT through contextual, collaborative, and meaningful learning activities. Based on these outcomes, it is recommended that teachers more widely adopt the PjBL model in social studies and other subjects to cultivate students' critical and creative thinking skills from an early stage. Educators should design projects that are closely connected to real-life contexts, actively engage students throughout each phase of the project, and allocate sufficient time for reflection to enhance learning effectiveness. Furthermore, future studies are encouraged to explore the application of PjBL across different educational levels and contexts in order to broaden empirical evidence and support the wider implementation of this model in improving the quality of elementary education.

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