

The Effect of Project-Based Learning Based Teaching Modules through Simple Terrarium Construction on Students' Critical Thinking Skills in Science and Social Studies (IPAS) for Fourth-Grade Students at MIN Kudus

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Abstract. This study addressed the low level of students' critical thinking skills in Integrated Science and Social Studies (IPAS) learning among fourth-grade students at Madrasah Ibtidaiyah Negeri (MIN) Kudus, which was influenced by less supportive instructional methods and assessments focusing on lower-order cognitive skills. The study aimed to examine the effect of a Project-Based Learning-based teaching module using a simple terrarium project on students' critical thinking skills. A quantitative quasi-experimental design with a non-equivalent control group was employed. The participants consisted of 54 fourth-grade students, with 27 students in the experimental class and 27 students in the control class, selected through purposive sampling. Data were collected using a validated and reliable critical thinking skills test administered as pretest and posttest. Data analysis included paired sample t-tests and independent sample t-tests. The findings revealed a significant improvement in students' critical thinking skills in the experimental group compared to the control group. The experimental group achieved higher mean percentages across all indicators, namely elementary clarification (84.6%), basic support (96.3%), inference (80.6%), advanced clarification (86.1%), and strategies and tactics (77.3%), while the control group obtained lower results (46.9%, 68.5%, 62.3%, 42.6%, and 39.8%, respectively). The paired sample t-test indicated a significant increase in the experimental group ($p = 0.000$; mean difference = -25.259), whereas the control group showed a smaller improvement ($p = 0.013$; mean difference = 4.148). Furthermore, the independent sample t-test confirmed a significant difference between the two groups ($p = 0.000$; mean difference = 32.000). These results demonstrate that Project-Based Learning-based teaching modules using simple terrarium projects effectively enhance elementary students' critical thinking skills in IPAS learning.

Keywords: *Critical thinking skills; elementary school; Integrated Science and Social Studies (IPAS); Project-Based Learning; teaching module; terrarium project*

INTRODUCTION

Education plays a strategic role in enhancing the quality of human resources, particularly in developing students' critical thinking skills—one of the essential 21st-century competencies known as the "4Cs": critical thinking, communication, collaboration, and creativity. This skill enables learners to analyze information, evaluate arguments, and solve problems in a logical, systematic, and evidence-based manner. Modern education focuses not only on mastering subject matter but also on developing higher-order thinking skills, effective communication, and productivity [1]. Furthermore, the Partnership for 21st Century Skills framework emphasizes the importance of mastering skills such as critical thinking, creativity, collaboration, communication, and independent learning as essential assets for students in facing global challenges [2].

Natural and Social Sciences (IPAS) instruction is designed to provide a holistic understanding through the integration of concepts from natural and social sciences, enabling students to comprehend phenomena comprehensively and develop inquiry skills through active engagement in the learning process [3]. Students possessing this ability tend to be better at grasping concepts in depth and applying them to real-life situations. Therefore, instructional efforts utilizing relevant and contextual media are needed to support the development of students' critical thinking skills [4], [5].

Preliminary research findings in the fourth-grade class at MIN Kudus indicate that students' critical thinking skills remain at a low level, evidenced by difficulties in problem-solving and limited active

participation in a learning process that tends to prioritize rote memorization and teacher-dominated instruction. One approach that can be employed to address these issues is the implementation of the Project-Based Learning model (PjBL). Theoretically, PjBL provides opportunities for learners to engage in systematic processes of investigation, problem-solving, and decision-making, while fostering learning activities through hands-on practice, collaboration, and reflection [6].

One innovation that can support the implementation of this model is the use of interactive learning media, such as simple terrariums. Serving as a representation of a mini-ecosystem, a terrarium allows students to directly observe the interactions between biotic and abiotic components, thereby making learning more contextual and providing a more meaningful educational experience [7]. Selecting the topic "Iklim dan Perubahannya" for Natural and Social Sciences (IPAS) instruction provides a relevant context for implementing project-based learning. By creating terrariums, students have the opportunity to learn about concepts such as climate change, the greenhouse effect, and the role of plants in maintaining environmental balance in a more contextual manner. This activity enables students to connect the concepts they have learned with real-world phenomena while fostering environmental awareness from an early age.

Several studies indicate that the implementation of Project-Based Learning (PjBL) contributes positively to enhancing students' critical thinking skills. Research by Fauziah et al. demonstrates that the implementation of Project-Based Learning (PjBL) significantly improves critical thinking skills compared to conventional instruction, as evidenced by an increase in the average score from 59.06 to 79.54 [8]. Research by Safitri and Ulfa demonstrates that the implementation of Project-Based Learning through terrarium creation significantly enhances students' critical thinking skills, as evidenced by the experimental class's higher average post-test score (81.60) compared to the control class (60.43), with a significant difference ($p < 0.05$) [7]. Overall, the findings indicate that PjBL is a relevant and effective approach for supporting the development of students' critical thinking skills, particularly in IPAS learning at the elementary school level.

Based on the preceding explanation, this study aims to analyze students' critical thinking skills and examine the impact of a Project-Based Learning (PjBL) module—centered on creating simple terrariums—on the critical thinking skills of fourth-grade students at MIN Kudus during Natural and Social Sciences (IPAS) lessons. The study hypothesizes that the implementation of this Project-Based Learning (PjBL) module, involving the creation of simple terrariums, significantly influences the critical thinking skills of fourth-grade students at MIN Kudus in the context of IPAS instruction.

METHODS

Study Area

This study was conducted at Madrasah Ibtidaiyah Negeri (MIN) Kudus, located in Kudus Regency, Central Java, Indonesia. The research subjects were fourth-grade students—specifically those in classes IV-B and IV-D, each comprising 27 students. The study was carried out during the even semester of the 2024/2025 academic year, specifically from April to May 2025.

Procedures

Research Design and Participants

This study employed a quasi-experimental design—specifically the non-equivalent control group type—involving two groups (experimental and control) that underwent pretests and posttests; the experimental group received PjBL-based instruction involving the creation of simple terrariums, whereas the control group did not. The study sample consisted of two classes, Class IV D as the experimental group and Class IV B as the control group each comprising 27 students selected through purposive sampling.

Research Variables

This study involves two variables:

- 1. Independent variable: a Project-Based Learning-based teaching module involving the creation of a simple terrarium.**
- 2. Dependent variable: students' critical thinking skills.**

Critical thinking skills are measured based on indicators: *elementary clarification*, *basic support*, *inference*, *advanced clarification*, *serta strategies and tactics*.

Instrument and Data Collection

Data were collected through written tests specifically pre-tests and post-tests to measure critical thinking skills, alongside documentation serving as supporting data. The instruments were validated using Aiken's V, and their reliability was assessed using *Cronbach's Alpha*.

Data Analysis

Data analysis was conducted to test the research hypotheses; all analyses were performed using SPSS software version 25. Prior to hypothesis testing, prerequisite tests were carried out, including a normality test using the Kolmogorov-Smirnov test and a homogeneity test using Levene's test, with a significance level of 0.05. Subsequently, hypothesis testing was conducted using:

Paired sample t-test to determine the difference between pretest and posttest scores within each group.

Independent-sample t-test to determine the difference in critical thinking skills between the experimental group and the control group.

RESULTS AND DISCUSSION

Before to hypothesis testing, the research instruments and data were analyzed using validity tests, reliability tests, difficulty level analysis, discrimination power analysis, normality tests, and homogeneity tests.

Validity Test

The validity of the instruments in this study was assessed using content validity, evaluated by three experts using Aiken's V coefficient. The validation process covered the pretest–posttest instruments, the Project-Based Learning (PjBL)-based teaching module, and the student worksheets (LKPD). An instrument was considered valid if it achieved an Aiken's V value of ≥ 0.80 . A summary of the validity test results is presented in Table 1.

Table 1. Summary of Results of Validity Test of Research Instruments Using Aiken's V Coefficient

Instrument	Number of Items/Indicators	Aiken's V Value Range	Category	Note
Instrument pretest–posttest	10 items	0.83–0.91 (average per item)	High validity	All items are suitable for use
PjBL-based teaching module	34 indicators	0.75–1.00	Moderate–high validity	27 indicators (79%) high validity and 7 indicators (21%) moderate validity
Student Worksheet (LKPD)	11 indicators	0.83–0.92	High validity	All indicators are suitable for use

Based on Table 1, all instruments used in the study met the criteria for content validity. The pretest–posttest instruments yielded average Aiken's V values ranging from 0.83 to 0.91, indicating high validity for all test items. Regarding the Project-Based Learning-based teaching module, 79% of the indicators fell into the high validity category and 21% into the moderate validity category, whereas all indicators for the student worksheets (LKPD) achieved Aiken's V values between 0.83 and 0.92, placing them in the high validity category. These results demonstrate that the research instruments are suitable for use in both the learning process and the collection of research data.

Reliability Test

The reliability of the critical thinking skills test instrument was analyzed using the Cronbach's Alpha coefficient with the aid of SPSS version 25. The reliability test results indicate that the instrument has a Cronbach's Alpha value of 0.664, thereby meeting the criteria for reliability and suitability for use in the study. The reliability test results are presented in Table 2.

Table 2. Reliability Test Results

Reliability Statistics	
Cronbach's Alpha	N of Items
.664	10

Based on Table 2, the critical thinking skills test instrument has a Cronbach's Alpha value of 0.664, indicating that the instrument possesses good internal consistency and is therefore suitable for use as a data collection tool in the study.

Project Implementation Outcomes and Students' Critical Thinking Skills

The implementation of the Project-Based Learning (PjBL) module was carried out through a project involving the creation of a simple terrarium within the context of a climate change lesson. Students worked

in groups, using Student Worksheets (LKPD) to observe the terrarium's condition over a three-day period and subsequently analyze their observations based on the concepts of the greenhouse effect and climate change. Throughout the activity, students demonstrated active engagement in conducting observations, interpreting data, drawing conclusions, and proposing solutions to the issues under study.

Student performance during the project was measured through an assessment of the Student Worksheets, covering five indicators. The assessment results showed an average score of 91.2, placing it in the "very high" category. A summary of the Student Worksheet assessment results is presented in Table 3.

Table 3. Summary of Student Worksheet Assessment Results

Group	Score	Final Score
1	24	96
2	24	96
3	22	88
4	24	96
5	20	80
Average	22,8	91,2

Analysis of critical thinking skills reveals that the experimental class achieved higher percentages than the control class across all indicators (Figure 1). The percentages for critical thinking skills in the experimental class were 84.6%, 96.3%, 80.6%, 86.1%, and 77.3%, respectively, whereas the control class achieved 46.9%, 68.5%, 62.3%, 42.6%, and 39.8%. The "basic support" indicator showed the highest achievement in both classes, while "strategies and tactics" was the indicator with the lowest achievement. These findings indicate that the implementation of a Project-Based Learning module centered on a simple terrarium-making project is more effective at enhancing students' critical thinking skills than conventional instruction.

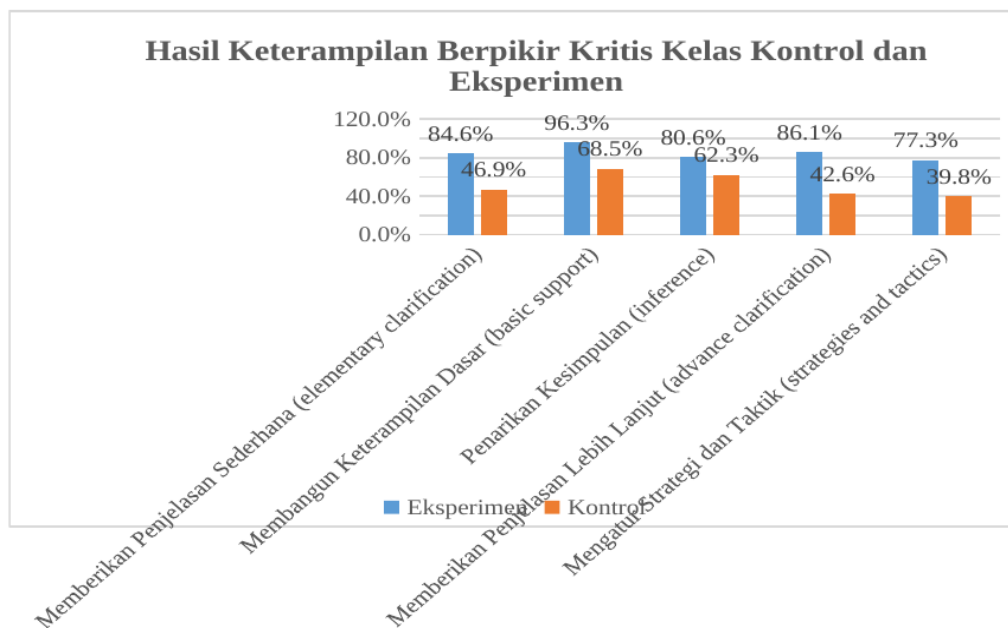


Figure 1. Comparison of Critical Thinking Skills between Students in the Experimental Class and the Control Class

Prerequisite Test

Prior to hypothesis testing, the research data were tested for normality and homogeneity to ensure that the assumptions for parametric analysis were met. A summary of the prerequisite test results is presented in Table 4.

Table 4. Results of Analysis Prerequisite Tests

Uji	Kelompok	Nilai Sig.	Keterangan
Normalitas (<i>Shapiro-Wilk</i>)	Pretest Eksperimen	0,364	Normal
	Posttest Eksperimen	0,404	Normal
	Pretest Kontrol	0,230	Normal
	Posttest Kontrol	0,177	Normal
Homogenitas (<i>Levene Test</i>)	Berdasarkan Mean	0,791	Homogen

Based on Table 4, all pretest and posttest data for both the experimental and control groups yielded significance values greater than 0.05, indicating a normal distribution. The homogeneity test results also showed a significance value of 0.791 (> 0.05), indicating that the variances of the two groups were homogeneous. Thus, all data met the assumptions required for parametric statistical analysis using the *t-test*.

Paired Sample t-Test Result

A *paired-sample t-test* was conducted to determine the difference between pretest and posttest scores for each group. The test results are presented in Table 5.

Table 5. Paired Sample t-Test Result

Group	<i>t</i>	<i>Sig. (2-tailed)</i>	<i>Mean Difference</i>	Keterangan
Eksperiment	-8,406	0,000	-25,259	Significant
Control	2,665	0,013	4,148	Significant

Based on Table 5, the paired-sample *t-test* results indicate a significant difference between pretest and posttest scores in the experimental class ($p < 0.05$). The improvement in critical thinking skills was greater in the experimental class than in the control class, as evidenced by a mean difference of -25.259, compared to 4.148 for the control class. These findings demonstrate that the implementation of a Project-Based Learning (PjBL) based teaching module centered on a simple terrarium-making project effectively enhances students' critical thinking skills.

Independent Sample t-Test Result

An *independent sample t-test* was conducted to determine the difference in mean post-test results between the experimental and control classes after the administration of different treatments. The test results are presented in Table 6.

Table 6. Independent Sample t-Test Result

Group	<i>t</i>	<i>Sig. (2-tailed)</i>	<i>Mean Difference</i>	Keterangan
Eksperiment vs Control	12,624	0,000	32,000	Significant

Based on Table 6, the *independent sample t-test* results show a significance value of 0.000 ($p < 0.05$), indicating a significant difference between the post-test results of the experimental class and the control class. The mean difference of 32.000 demonstrates that the average critical thinking skills of students in the experimental class were higher than those in the control class. These results indicate that the use of a Project-Based Learning module—centered on a simple terrarium-making project—significantly influenced the improvement of students' critical thinking skills.

Discussion

Students' Critical Thinking Skills in the Natural and Social Sciences (IPAS) Subject in Grade IV at MIN Kudus

Research results indicate that the critical thinking skills of students in classes using Project-Based Learning (PjBL) modules—specifically involving a simple terrarium-making project—were higher than those of students in classes receiving conventional instruction. These findings demonstrate that the implementation of PjBL fosters student-centered learning through contextual activities, thereby encouraging students to observe phenomena, analyze information, connect concepts to real-world conditions, and formulate solutions based on their observations. Such activities provide a meaningful learning experience, as students are directly engaged in the processes of inquiry and problem-solving related to the topics of climate change and the greenhouse effect.

These findings align with the characteristics of PjBL, which positions students as the central agents in the learning process. Through a simple terrarium project, students not only learn about climate change concepts theoretically but also gain hands-on experience observing changes in temperature, humidity, and plant conditions as representations of a closed ecosystem. The processes of observation, discussion, data analysis, and conclusion formulation encourage students to develop critical thinking skills by making decisions based on empirical evidence. These results reinforce the view of Fitriani et al., who state that PjBL-based learning modules are effective in enhancing critical thinking skills because they provide students with opportunities to observe, reason, and make logical decisions based on analysis [9].

Analysis based on critical thinking skill indicators reveals that the experimental class achieved higher results across all indicators compared to the control class. The "basic support" indicator recorded the highest percentage (96.3%), demonstrating that students were capable of providing relevant reasons and evidence to support an argument. Conversely, the "strategies and tactics" indicator showed the lowest percentage (77.3%), indicating that the ability to devise problem-solving strategies still requires strengthening, despite the experimental class outperforming the control group in this area. The variation in performance across indicators suggests that Project-Based Learning (PjBL) is more effective at rapidly developing students' abilities to identify information and construct arguments than it is at fostering the ability to design problem-solving strategies, a skill that requires sustained practice.

The results of this study align with the research by Hasibuan et al., which indicates that the implementation of PjBL contributes to enhancing critical thinking skills, particularly in formulating logical reasons and evidence [10]. This finding is also supported by Suharyati and Arga, who state that project-

based learning can enhance students' ability to construct arguments systematically through collaborative activities and inquiry [11]. On the other hand, research by Widiawati et al. indicates that although PjBL is effective in enhancing critical thinking skills, students still require guidance in independently determining problem-solving strategies [12]. Therefore, the results of this study further confirm that a Project-Based Learning module centered on creating simple terrariums serves as an effective instructional alternative for developing students' critical thinking skills in the IPAS subject at the elementary school level.

The Effect of Implementing a Project-Based Learning (PjBL) Module Involving the Creation of Simple Terrariums on the Critical Thinking Skills of Fourth-Grade Students in the IPAS Subject at MIN Kudus

The research results indicate that the implementation of a Project-Based Learning (PjBL)-based teaching module—centered on a simple terrarium-making project—significantly enhances students' critical thinking skills in Natural and Social Sciences (IPAS) instruction. Paired-sample t-test results reveal a significant improvement in the experimental class following the implementation of the PjBL-based module, while independent-sample t-test results show that students in the experimental class demonstrated higher critical thinking skills compared to those in the control class. These findings suggest that project-based learning is more effective than conventional instruction in developing students' critical thinking skills.

The enhancement of critical thinking skills was driven by the characteristics of Project-Based Learning (PjBL), which positions students at the center of the learning process through inquiry-based activities addressing real-world problems. In this study, students engaged in the PjBL stages, ranging from identifying climate change issues and designing a project to create a simple terrarium, to observing changes within the terrarium, analyzing observations, and finally presenting and evaluating the project outcomes. This sequence of activities provided students with opportunities to develop skills in analyzing information, evaluating evidence, drawing conclusions, and determining solutions based on the data obtained. This process aligns with constructivist theory, which posits that knowledge is built through authentic learning experiences and the active involvement of students in constructing their own understanding.

In addition to the influence of the Project-Based Learning (PjBL) model, the improvement in critical thinking skills was also supported by the use of instructional modules designed in alignment with the PjBL framework. These modules served not only as learning resources but also provided a systematic activity flow—incorporating learning objectives, project steps, guidelines for using student worksheets (LKPD), and reflection activities—that guided students through the critical thinking process. The structured design of learning activities helped students execute each project stage with greater focus, thereby optimizing the processes of observation, discussion, analysis, and drawing conclusions. Thus, the enhancement of critical thinking skills observed in this study resulted from the synergy between the use of structured instructional modules and the implementation of the Project-Based Learning model.

The results of this study align with the research by Pratiwi et al., which demonstrates that Project-Based Learning-based e-modules are effective in enhancing students' critical thinking skills through the presentation of systematic, problem-solving-oriented learning activities [13]. This finding is also supported by Fauziah et al., who state that the implementation of PjBL results in a greater improvement in critical thinking skills compared to conventional instruction, as it provides learners with the opportunity to learn through direct experience [8]. Furthermore, Salsabila and Widiyono reported that the implementation of PjBL in IPAS instruction significantly enhanced critical thinking skills through observation, collaboration, and contextual problem-solving activities [14]. The consistency of these findings reinforces the conclusion that integrating PjBL-based teaching modules with contextual projects is an effective instructional strategy for developing the critical thinking skills of elementary school students.

Overall, the results of this study indicate that a Project-Based Learning module centered on creating simple terrariums fosters active, contextual, and learner-centered instruction. The learning experiences gained during the project not only enhanced understanding of concepts related to climate change and the greenhouse effect but also cultivated students' higher-order thinking skills through observation, analysis, collaboration, reflection, and problem-solving activities. Consequently, this teaching module offers a potential alternative for instruction that supports the implementation of the “Kurikulum Merdeka” while facilitating the development of students' critical thinking skills in the IPAS (Natural and Social Sciences) subject.

CONCLUSION

This study demonstrates that the implementation of a Project-Based Learning (PjBL)-based teaching module—featuring a simple terrarium-making project—is effective in enhancing the critical thinking skills of fourth-grade students during Natural and Social Sciences (IPAS) lessons at MIN Kudus. Students in the experimental class achieved higher scores across all critical thinking skill indicators compared to the

control class, with the "basic support" indicator showing the highest level of achievement. Results from paired-sample and independent-sample t-tests further indicate a significant improvement following the implementation of the PjBL-based module, as well as a significant difference between the experimental and control classes. These findings suggest that a PjBL-based teaching module integrated with a simple terrarium project serves as an effective instructional alternative for developing students' critical thinking skills in primary school IPAS education

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