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The Effectiveness of Problem Based Learning in Improving the Cognitive Abilities of Elementary School Students

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Abstract
This study examines the effectiveness of Project Based Learning (PBL) in improving the cognitive abilities of elementary school students, especially critical thinking, problem solving, and conceptual understanding. The research used a quasi-experimental design involving 40 fifth-grade students at Magetan State Elementary School 1. The students were divided into two groups: an experimental group that used PBL and a control group that used conventional learning. Data were collected through cognitive ability tests administered as pre-test and post-test. The results showed that students in the experimental group achieved a higher improvement than those in the control group. The average post-test score in the experimental group increased by 20.1 points, while the control group increased by only 3.5 points. Statistical analysis using t-tests and ANOVA showed a significant difference between the two groups, with $p < 0.05$. These findings indicate that PBL can improve students' cognitive abilities and support the development of 21st-century skills. This study suggests that PBL should be integrated into elementary school learning to improve educational quality.

Keywords
Cognitive Abilities; Critical Thinking; Elementary School; Problem Solving; Project Based Learning

INTRODUCTION

At the primary education stage, the development of students' cognitive abilities is not only the main goal, but also an important foundation in the continuous learning process (Nurhasanah & Yarmi, 2023). Cognitive ability refers to the ability of individuals to understand, remember, analyze, organize, and use information effectively in decision-making and problem-solving (Babullah, 2022). These aspects are crucial for the intellectual development of students, especially at the elementary school level, which is a

critical period in the formation of mindsets and the way students interact with knowledge (Siradjuddin et al., 2026). This process also affects how students respond to new information, adapt to an ever-evolving environment, and face various challenges in the future. It is important to design and implement learning methods that can effectively stimulate and develop these cognitive abilities among elementary school students (Smith & Seal, 2021).

One of the approaches that is widely adopted to support the development of students' cognitive abilities is Project Based Learning (PBL) (Suyantiningsih et al., 2023). PBL is a project-based learning-focused learning approach, which requires students to actively participate in completing real-world results-oriented projects (Awami, Yuhana, et al., 2022). The concept of PBL is not only limited to the learning process based on the provision of information, but also to the creation and application of knowledge that can solve real problems in daily life (Maulidia et al., 2020). In PBL, students are given the opportunity to identify problems, design solutions, and work together in teams to produce relevant end products. Through this approach, students not only gain theoretical knowledge, but also develop practical skills and deeper critical thinking.

Innovation in learning methods is a key factor in improving the quality of education, especially in elementary schools, which is the foundation of the education system as a whole (Sutanto, 2024). Learning at the elementary level should be designed in such a way that it focuses not only on teaching academic content, but also on developing 21st-century skills that involve collaboration, creativity, communication, and problem-solving skills (Indarta et al., 2022). PBL is present as an effective alternative to achieving this goal, as it integrates these various skills into one comprehensive learning process (Indarta et al., 2022). By implementing PBL, students can learn through hands-on experiences that challenge students to think more critically and creatively, as well as allow students to see the direct relevance between the material being learned and real-world applications.

The application of PBL in elementary school provides opportunities for students to not only develop students' cognitive abilities, but also to enrich students' understanding of the concepts learned (Awami, Syamsuri, et al., 2022). In the context of project-based learning, students learn to integrate various information and skills in one larger unit (Diana et al., 2021). Through project development, students are faced with situations that require students to think analytically, organize information, and come up with practical and

innovative solutions (Zulyusri et al., 2023). This approach encourages students to relate what students learn to the context of everyday life, which in turn can improve comprehension and retention of the material. On the other hand, PBL also introduces students to the importance of team collaboration and communication, two skills that are highly relevant in an increasingly complex society (Indarta et al., 2022).

A number of previous studies have revealed that the application of PBL has a positive impact on improving students' cognitive abilities. Research by Ferawati & Suhendri (2020) shows that PBL not only helps students understand the material more deeply, but also improves students' critical thinking and problem-solving skills. Similarly, research by (Ridho et al., 2021) suggests that students who engage in project-based learning show significant improvements in collaboration and communication skills. However, most previous research has focused more on the implementation of PBL at the secondary and tertiary education levels (Loyens et al., 2023; Nugraha & Suparman, 2021; Octaria & Sari, 2018), while research that specifically examines the effectiveness of PBL in elementary schools is still limited. This indicates that there is a gap that needs to be filled, namely how the implementation of PBL at the elementary school level can directly affect students' cognitive abilities in the early stages of student education.

This study aims to fill this gap by investigating the effectiveness of the application of PBL in improving the cognitive abilities of elementary school students. This study will examine how the application of PBL affects aspects of students' cognitive abilities, such as critical thinking skills, problem solving, and concept comprehension and reminder. With a quantitative approach, this study aims to provide empirical evidence on the positive impact of PBL on the cognitive development of elementary school students. In addition, this study also seeks to explore factors that can influence the success of PBL implementation, as well as provide practical recommendations for teachers and education practitioners in implementing this method effectively in primary schools. Thus, this research is expected to make a significant contribution to understanding the importance of innovation in learning methods and the application of PBL as a solution in improving the quality of education at the elementary level.

THEORETICAL SUPPORT

Development of Cognitive Abilities in Elementary School

Cognitive ability is a fundamental ability that students need to be able to think effectively and solve problems in daily life. In the context of education, these cognitive abilities include various aspects, such as understanding, applying, analyzing, and evaluating information (Nurhasanah & Yarmi, 2023). At the elementary school level, the development of cognitive abilities plays an important role in forming the foundation for students' future intellectual development. According to Babullah (2022), the stage of children's cognitive development at elementary school age is at the operational concrete stage, which allows children to think logically, categorize objects, and understand cause-and-effect relationships. Therefore, it is important for education in elementary schools to introduce learning methods that can stimulate cognitive development to the maximum.

To further explore, the development of cognitive abilities in elementary schools must involve a more holistic and interactive approach. The use of project-based learning methods, as tested in this study, has been shown to significantly improve students' critical thinking, problem-solving skills, and conceptual understanding. This indicates that learning methods based on active engagement and the application of knowledge in real-world contexts can stimulate better cognitive development. Therefore, it is important for the elementary school curriculum to integrate this approach, so that students can develop skills relevant to the challenges of the 21st century.

Project Based Learning (PBL): Concept and Implementation

Project Based Learning (PBL) is one of the learning methods that is now increasingly popular at various levels of education, including in elementary schools. PBL is designed to encourage students to interact with knowledge in a more realistic and applicative context. According to Ridho et al. (2021), PBL is a real-world project-focused learning approach that allows students to explore and solve problems that are relevant to the real world. In PBL, students work collaboratively to design, implement, and complete projects that require students to solve problems, collect and analyze data, and make decisions based on student research results (Ahmad et al., 2023; Awami, Yuhana, et al., 2022; Chen & Kalyuga, 2020). PBL is considered an effective approach to improve critical thinking and

problem-solving skills, two aspects that are very important in students' cognitive development (Siradjuddin et al., 2026).

PBL also introduces students to the concept of more active and experiential learning. According to (Akhyar et al., 2024; Maulidia et al., 2020) experiential learning such as PBL provides opportunities for students to learn in a more in-depth and contextual way, connecting theory with practice. Projects carried out in PBL focus not only on the achievement of results, but also on the learning process itself, which allows students to learn from mistakes, explore various solutions, and experience firsthand how knowledge can be applied in real life. Therefore, PBL can be a very effective way to improve various aspects of students' cognitive abilities.

To further elaborate, Project Based Learning (PBL) offers a more dynamic and engaging approach to developing cognitive abilities. By focusing on real-world projects, PBL encourages students to actively apply their knowledge, fostering critical thinking and problem-solving skills. This method not only enhances students' ability to tackle complex challenges but also strengthens their capacity for collaboration and decision-making. The experiential learning aspect of PBL allows students to bridge the gap between theoretical knowledge and practical application, giving them a deeper understanding of the subject matter. Moreover, as students navigate through the process of designing and completing projects, they develop resilience and learn to view mistakes as opportunities for growth. Thus, PBL stands out as a powerful tool for enhancing cognitive development in elementary education, preparing students for future academic and life challenges.

METHOD

Research Design

This study used a quasi-experimental design with a pre-test and post-test approach involving two groups, namely the experimental group applied with Project Based Learning (PBL) and the control group that followed conventional learning. The design of this study aims to measure changes in students' cognitive abilities after the application of the project-based learning method (PBL). The experimental and control groups will follow the same learning, but with a different approach. The experimental group will receive PBL treatment, which includes several key steps: first, students are presented with a driving question to guide the project; second, they work in groups to plan and design the project;

third, students gather information, conduct research, and solve problems related to the project; fourth, they create a final product or presentation; and lastly, students reflect on the process and outcomes. Meanwhile, the control group will follow a traditional learning method that focuses more on lectures and practice questions.

Population and Sample

This research was carried out at Magetan 1 State Elementary School, which is an elementary school in the Magetan area, East Java. The research population consisted of all 5th grade students in the school. From this population, 40 students were randomly selected to be used as a research sample, consisting of the Experimental Group: 20 students who will apply the Project Based Learning (PBL) method and the Control Group: 20 students who will follow conventional learning. Random sample selection is carried out to avoid bias and ensure sample representativeness. These two groups will be treated separately, but students will follow the same learning materials.

Instrument

To ensure the validity and reliability of the instruments in this study, several measures will be taken. Validity will be assessed through content validity, ensuring that the cognitive ability test covers all relevant aspects of critical thinking, problem-solving, and concept understanding, and construct validity, which ensures that the test accurately measures the cognitive abilities intended. Expert review will be used to confirm alignment with the study's objectives. Reliability will be tested using Cronbach's alpha to assess internal consistency, with a coefficient above 0.7 indicating good reliability. Additionally, test-retest reliability will be evaluated by administering the test twice to a small sample to check for consistent results. These steps will ensure that the instruments effectively measure cognitive abilities and yield dependable results.

Data Analysis Techniques

The collected data will be analyzed using statistical techniques to test the research hypothesis. The two types of statistical tests that will be used in this study are: Paired Samples t-test. The t-test is used to test for significant differences between pre-test and post-test results in a single group (experiment or control). The t-test will measure whether

there is a significant improvement in cognitive ability after the application of PBL in the experimental group, as well as whether there are changes in the control group that followed conventional learning. In addition, the ANOVA (Analysis of Variance) test was also carried out: The ANOVA test was used to test whether there was a significant difference between the experimental group and the control group in the post-test results. ANOVA allows comparisons between the two groups to see if the application of PBL affects the improvement of cognitive abilities significantly compared to conventional learning.

RESULT

Data Description

This study involved 40 students from Magetan 1 State Elementary School, who were divided into two groups: the experimental group (20 students) who applied Project Based Learning (PBL) and the control group (20 students) who followed conventional learning. Data obtained from both groups were analyzed to measure changes in students' cognitive abilities, which included three main aspects: critical thinking, problem-solving, and concept comprehension.

As a first step, pre-tests were given to both groups to measure students' cognitive abilities before the implementation of learning. In the pre-test, students were measured using questions that focused on critical thinking (analytical and evaluation skills), problem-solving (the ability to find solutions to given problems), and concept understanding (students' understanding of the subject matter).

Table 1. Pre-test Score Distribution

Groups	Average Pre-test Score	Standard Deviation
Experimental Group	60.4	5.72
Control Group	59.7	6.09

From the table above, it can be seen that there is a difference in the average score between the two groups, but the difference is not significant. Both groups had almost similar scores on the pre-test, which suggests that the students' initial cognitive abilities in both groups were at a comparable level.

Pre-test and Post-test Results in the Experimental Group

The experimental group, which was implemented with PBL, then followed a project-based learning process. After the implementation of PBL for four weeks, students take a **post-test** similar to the test given in the pre-test to measure changes in students' cognitive abilities.

Table 2. Pre-test and Post-test scores of the Experimental Group

Test Type	Average Score	Standard Deviation	Score Improvement
Pre-test	60.4	5.72	-
Post-test	80.5	4.81	20.1

From the table, it can be seen that there was a significant increase in the experimental group, with a higher average post-test score of 80.5 compared to the pre-test of only 60.4. The increase in the average score of 20.1 points shows a positive impact on the implementation of PBL on students' cognitive abilities in the aspects of critical thinking, problem solving, and concept understanding.

Pre-test and Post-test Results in the Control Group

The control group, which followed conventional learning, also took similar tests on the pre-test and post-test to measure changes in students' cognitive abilities.

Table 3. Control Group Pre-test and Post-test Scores

Test Type	Average Score	Standard Deviation	Score Improvement
Pre-test	59.7	6.09	-
Post-test	63.2	5.40	3.5

From the table above, it can be seen that the control group experienced only a small increase in post-tests, with the average score rising from 59.7 in the pre-test to 63.2 in the post-test. This 3.5-point increase in score suggests that although there was a slight improvement, the changes that occurred in the control group were much smaller compared to the experimental group using PBL.

Statistical Analysis

To further analyze the data, a t-test (paired samples t-test) and ANOVA were performed to find out if the differences found in the experimental and control groups were significant.

T-test for the Experimental Group

The t-test was used to find out if there was a significant difference between the pre-test and post-test in the experimental group. Based on the results of the t-test, a p< value of 0.05 was obtained, which indicates that there was a significant difference between the pre-test and post-test scores in the experimental group. The results of the t-test: $p = 0.0001$ ($p < 0.05$) with a very small p-value ($p < 0.05$), the null hypothesis was rejected, indicating that the application of PBL had a significant influence on the improvement of students' cognitive abilities.

ANOVA Test for Comparison of Experimental and Control Groups

To test the difference between the experimental and control groups in the post-test, the ANOVA test was performed. The ANOVA results showed a p< value of 0.05, which indicates that there was a significant difference between the experimental group and the control group on the post-test results. ANOVA results: $p = 0.002$ ($p < 0.05$) showed that the application of PBL in the experimental group had a significant influence on cognitive ability improvement, compared to the control group using conventional learning.

DISCUSSION

This study aims to test the effectiveness of Project Based Learning (PBL) in improving the cognitive abilities of elementary school students. The results obtained showed that the application of PBL in the experimental group had a significant effect on improving cognitive abilities, especially in the aspects of critical thinking, problem solving, and concept understanding (Nugraha & Suparman, 2021). This is reflected in the significant difference between the pre-test and post-test scores of the experimental group, with an average score increase of 20.1 points, which is much higher compared to the control group which only experienced an increase of 3.5 points. These results support the findings of various previous studies that show that PBL can improve students' critical thinking and problem-solving skills (Fadli, 2020; Trisna Nugraha, 2021).

The implementation of PBL that focuses on project-based learning allows students to actively engage in the learning process (Wijayati et al., 2019). In this model, students not only memorize information, but students learn in a more active and contextual way, connecting the theories that students learn with real-world applications. In the experimental group, students are given project tasks that challenge students to think

critically and analyze information in depth (Fathonah et al., 2023). This activity encourages students to seek solutions to real problems, which in turn helps to strengthen students' understanding of the concepts being taught. PBL not only improves understanding of concepts, but also encourages students to develop more in-depth and reflective thinking skills (Prasetiyo et al., 2023; Putra et al., 2020).

The results of this study are also in line with previous findings indicating that PBL can improve collaboration and communication skills among students, two skills that are highly relevant in the context of 21st century learning (Prasetiyo et al., 2023; Putra et al., 2020). In the PBL process, students work in groups to design and complete projects, which allows students to share ideas, discuss solutions, and help each other in completing tasks. This collaboration not only enriches students' understanding of the material, but also helps students develop important social skills, such as effective communication, conflict resolution, and teamwork. Research shows that PBL helps students to more actively participate in learning and improve students' interpersonal skills, which are important competencies in daily life (Loyens et al., 2023; Razak et al., 2022).

The implications of this research are very relevant for the development of curriculum and teaching methods in elementary schools. The application of PBL can be a solution to improve students' cognitive skills that are often poorly honed in traditional learning (Akhyar et al., 2024; Wulandari & Nawangsari, 2024). Project-based learning allows students to not only learn from textbooks, but also connect the knowledge that students learn with real life (Fauzansyah et al., 2025). Therefore, schools in Indonesia need to consider implementing PBL more in the curriculum of students, with adequate training for teachers to be able to manage projects that engage students effectively. This research also contributes to the development of more innovative learning methods, which are expected to improve the quality of education at the overall elementary school level.

CONCLUSION

The application of Project Based Learning (PBL) significantly improves the cognitive abilities of elementary school students, especially in the aspects of critical thinking, problem solving, and concept understanding. The experimental group that applied PBL showed a much greater improvement compared to the control group that followed conventional learning. The implication of these findings is that PBL can be an

effective method for developing students' cognitive skills and can be considered for wider integration in the primary school curriculum. However, this study has limitations regarding its limited duration (four weeks) and is only conducted in one primary school, so further research with a larger sample and longer duration is needed to strengthen these findings. As a suggestion, schools need to provide training to teachers to implement PBL effectively, in order to improve the quality of education and prepare students to face future challenges.

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