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The Influence of Project Based Learning LKPD on Scientific Thinking Skills and Collaboration in Science Learning in Class V of Elementary School

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Abstract: This research aims to measure the effectiveness of Student Worksheets (LKPD) based on Project Based Learning (PBL) in improving students' cooperation and scientific thinking skills in science subjects in elementary schools. Using a quasi-experimental design with a nonequivalent control group, this research involved 60 fifth grade students who were divided into an experimental group (using PBL-based LKPD) and a control group (using conventional methods). Instrument is a questionnaire to measure cooperation and a written test to measure scientific thinking abilities. The results of the analysis show that the average student collaboration score in the experimental group was 85.3, higher than the control group which only reached 78.4. The average score for scientific thinking ability in the experimental group reached 82.7, compared to 75.6 in the control group. Data analysis using the independent t test, after fulfilling the assumptions of normality and homogeneity of variance, showed statistically significant differences with a p value < 0.05. Results indicate that the use of PBL-based LKPD is more effective in increasing students' cooperation and scientific thinking abilities compared to conventional methods. This research suggests a wider application of PBL in science learning in elementary schools to optimize students' collaborative and scientific thinking skills.

Keywords: Collaboration; Elementary school; Project Based Learning (PBL); Science; Scientific thinking ability; Student worksheets (LKPD)

Introduction

Learning in elementary schools plays an important role in forming the foundation of students' knowledge and skills which will influence their learning process at the next level of education (Marta et al., 2020; Wahira et al., 2024). One of the most essential subjects in the elementary school curriculum is Natural Sciences (IPA) (Marni et al., 2023; Yulia et al., 2023). This subject not only aims to provide basic knowledge about nature and the environment, but also to develop scientific thinking skills, analytical abilities, and cooperative attitudes among students (Fitriyanti & Zikri, 2020; Mulyani & F, 2017).

The importance of developing scientific thinking skills and collaboration in science learning encourages educators to look for more effective learning approaches. One approach that is increasingly popular and widely applied is Project Based Learning (PBL) (Ssemugenyi, 2023). PBL allows students to learn through real projects that are relevant to everyday life, so that students not only understand concepts theoretically, but also through direct experience (Ruzadiana et al., 2018).

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Through PBL, students are encouraged to work collaboratively in teams, identify real problems, formulate solutions, and compile and present the results of their work (Sutiani et al., 2017). This process fosters various important skills such as critical thinking, analysis, problem solving, and of course collaboration (Chiang & Lee, 2016). The implementation of PBL is also expected to increase students' learning motivation, because they are directly involved in a more interactive and contextual learning process. In its implementation, PBL-based Student Worksheets (LKPD) become a very important tool (Ruzadiana et al., 2018). This worksheet is designed to guide students through every step in project implementation, from planning to evaluation. With LKPD, students are expected to be able to organize their thoughts, understand tasks more clearly, and ensure that each stage of the project is carried out well (Rofiah, 2024; Zulkurnia et al., 2017). The use of PBL-based LKPD also allows teachers to monitor and assess student learning processes and outcomes more comprehensively.

Various previous studies have shown the positive impact of using PBL on various aspects of student learning. For example, PBL can improve students' critical thinking skills in elementary schools (Pramita et al., 2022). Meanwhile, research by Fitria et al. (2019) found that PBL was effective in increasing students' learning motivation and cooperation. However, even though a lot of research has been carried out, there is still a gap regarding the implementation of PBL-based LKPD specifically in improving students' cooperation and scientific thinking abilities, especially in science subjects in elementary schools.

In practice, students often face various obstacles when using PBL-based LKPD. One of the main problems is difficulty in understanding the complex and detailed instructions presented in the LKPD (Azmi et al., 2018). This often makes students feel confused and hesitant about taking the next step in the project, which ultimately hinders their learning process (Waluyo et al., 2016).

Apart from that, students' ability to organize project steps is also a challenge in itself. Some students may not be familiar with a systematic planning process, so they have difficulty prioritizing tasks or managing their time effectively. As a result, the projects they work on are often not completed on time or do not achieve the expected results.

Another problem that arises is related to teamwork. In PBL projects, students are required to work together with a group of friends (Barnard et al., 2018). However, not all students have good collaborative skills. Sometimes, students who excel in academics tend to dominate work, while other students become passive and contribute less. This can create an imbalance within the team, potentially reducing the quality of project outcomes and hindering the development of students' collaboration skills.

Experience working independently is also one of the challenges in using PBL-based LKPD (Sada et al., 2016). Some students may not be used to working without direct direction from the teacher, so they have difficulty making decisions or finding solutions when facing problems in projects. This lack of experience can reduce the effectiveness of LKPD as a learning aid.

Although many studies have examined PBL in general, this research offers novelties or novelty with a specific focus on the use of PBL-based LKPD in the context of science learning in elementary schools (Saputra et al., 2023), especially in increasing collaboration and students' scientific thinking abilities (Diana, 2018). This research also attempts to answer various problems faced by students in using LKPD, which have not been widely discussed in previous research.

Therefore, this research focuses on studying the effect of using Project Based Learning LKPD on cooperation and scientific thinking skills in science subjects in elementary schools. It is hoped that the results of this research can provide deeper insight into the effectiveness of this approach as well as solutions to the problems faced, so that it can be implemented better in the future.

Method

This research uses a quantitative approach with a quasi-experimental design (Creswell, 2017; Uhyat, 2013). This design was chosen because it allows researchers to directly measure the effect of using Project Based Learning (PBL)-based Student Worksheets (LKPD) on students' cooperation and scientific thinking abilities in science subjects in elementary schools. In this study, a nonequivalent control group design was used, where there were two groups, namely the experimental group and the control group, without subject randomization. This approach aims to see differences in learning outcomes between students who use PBL-based LKPD and those who learn using conventional methods. The population in this study were all fifth grade students in several elementary schools in the Agam district, which used the independent curriculum in science learning (Sugiyono, 2020). From this population, the sample was selected using a purposive sampling technique, involving two classes from two schools that had similar characteristics, both in terms of students' academic abilities, school facilities, and socio-economic background.

The first class will be used as an experimental group which will use PBL-based LKPD, while the second class will be used as a control group which will use conventional learning methods without PBL-based LKPD. Each class consists of around 30 students, so the total sample involved in this research was 60 students. The instruments used in this research include various measurement tools designed to assess students' cooperation and scientific thinking abilities. The first instrument is a questionnaire adapted from a collaboration instrument that has been validated in previous research. This questionnaire is designed to measure various aspects of cooperation, such as communication, contribution to the group, joint decision making, and conflict resolution. In addition, students' scientific thinking abilities are measured through a written test consisting of multiple choice questions and essays designed in accordance with the fifth grade science curriculum. This test measures the ability to analyze, identify problems, formulate hypotheses, interpret data and draw conclusions. Observations are also carried out during the learning process to monitor student participation, interactions between students, and the implementation of PBL-based LKPD. Before use, all of these instruments are tested for validity and reliability to ensure that they can accurately measure what they are supposed to measure.

The data collected from this research was analyzed using quantitative statistical analysis techniques. The first step in this analysis is to test the normality and homogeneity of the data to ensure that the data meets parametric statistical assumptions. The normality test was carried out using the Kolmogorov-Smirnov test, while the homogeneity of variance test was carried out using the Levene test. If the data is proven to be normal and homogeneous, then the independent t-test will be used to test the hypothesis. However, if the data do not meet these assumptions, non-parametric tests such as the Mann-Whitney test will be applied. Apart from that, descriptive analysis was also carried out to describe the distribution of students' collaboration scores and scientific thinking abilities in both groups, including the mean, median and standard deviation scores. The results of this statistical test are then interpreted to determine whether there are significant differences between the experimental group and the control group in terms of cooperation and scientific thinking abilities. This interpretation is very important to answer the research hypothesis and provide practical recommendations related to the implementation of PBL-based LKPD in elementary schools. With this structured research method, it is hoped that the research can provide a clear picture of the effectiveness of PBL-based LKPD in improving students' cooperation and scientific thinking abilities, as well as providing solutions to the challenges that arise in applying this method.

Result and Discussion

This research aims to determine the effect of using Student Worksheets (LKPD) based on Project Based Learning (PBL) on students' cooperation and scientific thinking abilities in science subjects in elementary schools. After carrying out a series of data collection and analysis processes, the results of this research will be presented to provide an overview of the effectiveness of using Student Worksheets (LKPD) based on Project Based Learning (PBL) on students' cooperation and scientific thinking abilities.

This analysis includes data description, statistical assumption testing, and hypothesis testing which aims to answer research questions and test the hypotheses that have been formulated. These results will provide deeper insight into the impact of implementing PBL in science learning in elementary schools. The following is a description of research data on students' cooperation abilities and scientific thinking abilities in science learning in Tables 1 and 2.

Table 1. Description of student collaboration data

Class	Average	N	Dev
Experiment	65.4	30	8.3
Control	78.2	30	7.1

In Table 1 it is explained that in the experimental group, the average cooperation score was 85.3 with a standard deviation of 5.2, which shows that the majority of students in this group had a good and relatively consistent level of cooperation. On the other hand, the control group had a mean score of 78.4 with a standard deviation of 6.1, indicating that although there was cooperation among students, the level was lower and more variable compared to the experimental group.

Table 2. Description of students' scientific thinking abilities

Class	Average	N	Dev
Experiment	65.4	30	8.3
Control	78.2	30	7.1

In Table 2 it is explained that the average scientific thinking ability score in the experimental group is 82.7 with a standard deviation of 4.8, which shows that students in this group have higher and uniform scientific thinking abilities. The control group had an average score of 75.6 with a standard deviation of 5.5, which indicates that students' scientific thinking abilities in this

group were lower and varied. These results indicate that the use of PBL-based LKPD has a significant positive impact on students' cooperation and scientific thinking abilities compared to conventional learning methods. Before carrying out further analysis using an independent t-test, normality and homogeneity tests were first carried out to ensure that the data obtained met the required statistical assumptions. The normality test is carried out to evaluate whether the data is normally distributed, while the homogeneity of variance test is used to check the uniformity of variance between groups. The results of these two tests will determine whether the parametric test can be used validly in this research. The results of the normality and homogeneity tests can be seen in Table 3.

Table 3. Normality and homogeneity test

Testing	Experiment	Control	Information
Normality Test	> 0.05	> 0.05	Normally distributed data
Homogeneity Test	> 0.05	> 0.05	Homogeneous data variance

In Table 3, the normality test results are explained, showing that the p-value for both groups (experimental and control) is greater than 0.05. This means that the data on cooperation scores and scientific thinking abilities are normally distributed in both groups. This normal distribution is one of the basic assumptions for proceeding to parametric tests such as the t-test. The homogeneity of variance test also shows that the p-value for both groups is greater than 0.05. This shows that the data variance between the experimental and control groups is homogeneous or the same. This homogeneity of variance is important to ensure that the comparison between the two groups is fair and valid.

After ensuring that the data meets the assumptions of normality and homogeneity of variance, the next step in the analysis is to carry out an independent t-test. This test was carried out to compare the average scores between the experimental group and the control group, especially in the variables of cooperation and scientific thinking ability. This independent t-test aims to determine whether there is a statistically significant difference between the two groups, which will provide an overview of the effectiveness of using Project Based Learning (PBL) LKPD in science learning in elementary schools. The t-test results can be seen in Table 4.

Table 4. T-Test results

Variable	Experiment	Control	t value	p-value	Information
Cooperation	85.3	78.4	5.12	< 0.05	Significant
Scientific thinking ability	82.7	75.6	4.67	< 0.05	Significant

In Table 4 it is explained that the t test results show that the average cooperation score in the experimental group (85.3) is higher than the control group (78.4). The t value obtained is 5.12 with a p-value < 0.05, which means this difference is statistically significant. This shows that the use of PBL-based LKPD significantly increases student collaboration compared to conventional learning methods. In scientific thinking ability, the average score in the experimental group was 82.7, while in the control group it was 75.6. The t value obtained was 4.67 with p-value < 0.05, indicating a statistically significant difference. This indicates that PBL-based LKPD also has a significant positive influence on students' scientific thinking abilities. These two test results show that there are significant differences between the experimental group and the control group in terms of cooperation and scientific thinking abilities, with the experimental group showing better results.

After carrying out an independent t-test to evaluate the differences between the experimental group that used Project Based Learning (PBL)-based Student Worksheets (LKPD) and the control group that used conventional learning methods, the next step was to interpret the test results. This interpretation aims to determine whether the use of PBL-based LKPD has a significant effect in increasing students' cooperation and scientific thinking abilities. The results of the interpretation will provide further understanding regarding the effectiveness of the PBL method in science learning in elementary schools. Interpretation of statistical test results can be seen in Table 5 below.

Table 5. Interpretation of statistical test results

Variable	Average Difference	p-value	Interpretation
Cooperation	6.9	< 0.05	The use of PBL-based LKPD significantly increases student collaboration
Scientific Thinking Ability	7.1	< 0.05	The use of PBL-based LKPD significantly increases students' scientific thinking abilities

In Table 5, it is explained that the average difference between the experimental group and the control group

in terms of cooperation is 6.9, with a p value < 0.05. This shows that the use of PBL-based LKPD has a significant effect in increasing student collaboration compared to conventional learning methods. Furthermore, the average difference between the experimental group and the control group in terms of scientific thinking ability was 7.1, also with a p value < 0.05. This means that the use of PBL-based LKPD significantly increases students' scientific thinking abilities compared to conventional learning methods. These results show that the implementation of PBL-based LKPD has a significant positive impact on the two variables measured, confirming that this method is more effective than conventional learning methods in the context of science learning in elementary schools.

This research shows that the use of Student Worksheets (LKPD) based on Project Based Learning (PBL) significantly increases students' cooperation and scientific thinking abilities compared to conventional learning methods. These findings are consistent with various previous studies that emphasize the effectiveness of PBL in improving students' collaborative and critical thinking skills. Eviyanti et al. (2017) found that PBL encouraged students to work together in groups to complete projects, thereby increasing their cooperation. Another study by Moutinho et al. (2015) revealed that PBL not only improves critical and analytical thinking skills, but also students' ability to work effectively in teams, which is essential in science learning in elementary schools.

Furthermore, this research supports previous findings which state that PBL can improve students' scientific thinking abilities. For example, research by Bramante & Colby (2012) shows that a project-based approach allows students to better understand scientific concepts and apply them in real situations. Similar findings were also reported by Sada et al. (2016), who stated that students involved in PBL showed significant improvements in their ability to identify problems, formulate hypotheses, and analyze data, all important aspects of scientific thinking.

Research by Yunitasari & Hardini (2021) also indicates that PBL is effective in developing higher-order thinking skills, including analysis, synthesis, and evaluation, which are all key components of scientific thinking. Srikan et al. (2021) further confirmed that students who learn through PBL have better critical thinking and problem solving skills compared to those who learn through traditional methods. Research by O' Leary et al. (2023) also shows that PBL has a long-term impact on students' ability to solve complex problems, which strengthens the findings of this research regarding the benefits of PBL in science learning.

One of the main advantages of this research is the application of a quasi-experimental design with a nonequivalent control group. Although this design carries a risk of bias due to the lack of randomization, selecting samples that have similar characteristics helps minimize bias and increase internal validity. Although randomization is not always possible in educational research, quasi-experimental designs remain a powerful method for testing hypotheses in educational contexts (Creswell, 2017). Thus, the results obtained from this research remain reliable and have high practical relevance.

This research is also superior in terms of the validity and reliability of the instruments used. The instruments used to measure cooperation and scientific thinking abilities have been validated through previous research, ensuring that the data obtained is accurate and reliable. The importance of instrument validity in educational research (Latief, 2009), and this research follows the procedures outlined to ensure that the instruments used have high validity and reliability (Sugiyono, 2020). This is very important to ensure that the research results reflect the true effects of the interventions carried out.

Apart from that, the use of direct observation during the learning process is another advantage of this research. Observation allows researchers to obtain qualitative data that enriches quantitative data from tests and questionnaires. Combining qualitative and quantitative data provides a more comprehensive view of the phenomenon under study, which is very important in the context of Education research (Adlini et al., 2022). In this study, direct observation provided additional insight into how the PBL-based worksheet was implemented and how students responded to it.

However, although this study provides strong evidence regarding the effectiveness of PBL, there are limitations that need to be acknowledged, especially regarding the generalizability of the findings. Because this study only involved a few elementary schools in a specific area, the results may not be fully generalizable to the wider population. Research with non-random samples has limitations in terms of generalization, although it can still provide valuable insights in more specific contexts (Sugiyono, 2014). Therefore, it is important to conduct further research with a broader scope to test the consistency of these findings in various contexts.

The results of this research have significant practical implications for educators and curriculum developers (Bentri et al., 2014). With evidence showing that PBL can improve collaboration and scientific thinking skills, teachers can be more confident in adopting and implementing this approach in their classrooms. The importance of approaches that encourage active and

collaborative learning in preparing students to face the challenges of the 21st century (Martinez, 2022). In this context, the results of this research provide empirical support for the application of PBL in science learning in elementary schools.

For future research, it is recommended that a broader study be conducted involving more schools and variations in students' socioeconomic backgrounds. In addition, longitudinal research is also recommended to observe the long-term development of students' scientific thinking and collaboration skills. The effects of PBL can develop and become stronger over time, so it is important to observe the long-term impacts of this approach (Wang, 2021). More in-depth studies could also explore how PBL influences other aspects of learning, such as student motivation and engagement.

Overall, this research succeeded in showing that the use of PBL-based LKPD has a significant positive impact on students' cooperation and scientific thinking abilities. These findings support the results of previous research and expand understanding of the effectiveness of PBL in elementary education contexts. Therefore, this research makes a significant contribution to educational literature and teaching practice, and encourages wider adoption of PBL methods in schools. This is also in line with the findings of Rahmadani (2017), which show that PBL not only improves academic achievement but also other important skills needed in everyday life.

Conclusion

This research proves that the use of Project Based Learning (PBL) based LKPD is effective in increasing cooperation and scientific thinking abilities of students in elementary schools. The average student collaboration score in the experimental group reached 85.3, higher than the control group with 78.4. Likewise, the scientific thinking score in the experimental group reached 82.7, while the control group was only 75.6. With significant results ($p < 0.05$), PBL is recommended to be implemented more widely in science learning in elementary schools.

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Authors contribution
Conceptualization, methodology, investigation, data curation, writing—original draft preparation, U.K. and Y.E.; validation, writing—review and editing, visualization, D.N. and U.R.; formal analysis, U.K. and P.; resources, U.R. and P. All authors have read and agreed to the published version of the manuscript.

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