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RESEARCH ARTICLE

Effectiveness of *Project Based Learning* (PjBL) Model on Mathematics Learning Outcomes of Elementary School Students

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ABSTRACT
This study analyzes the effectiveness of the Project-Based Learning (PjBL) model on primary school students' mathematics learning outcomes. The research highlights the importance of primary education in developing students' cognitive and analytical skills, addressing challenges such as low interest in mathematics. Using a quantitative design, 24 students were randomly sampled. Data were collected through pretests and posttests to measure students' mathematics learning outcomes before and after implementing the PjBL model. Descriptive statistics were employed to calculate the mean, standard deviation, and standard error. A paired samples t-test was conducted to compare pretest and posttest scores, revealing a significant improvement in learning outcomes (mean difference = -11.125, $p < 0.05$). The findings confirm that the PjBL model significantly enhances mathematics learning outcomes. This study concludes that the PjBL model is an effective instructional strategy to improve mathematics achievement in primary education.

Keywords: *Learning Effectiveness, PJBL, Learning Outcomes*

INTRODUCTION

Basic education serves as a foundation in students' academic development, where Mathematics subjects have an urgency in shaping cognitive and analytical skills (Dewi & Putra, 2022). Learning Mathematics not only aims to provide basic knowledge, but also to shape and improve critical thinking skills and problem-solving abilities needed in everyday life (La'ia & Harefa, 2021). The learning process in Mathematics can facilitate students in understanding abstract concepts and applying them in a practical way. However, suboptimal learning outcomes both in terms of understanding the material and achieving grades are often a challenge faced. In this case, students' mathematics grades and understanding of the material become important benchmarks in determining the success of an effective mathematics learning process.

In this case, it is necessary to explore and apply effective learning methods to overcome the obstacles experienced by teachers. Innovations in pedagogical approaches, such as the use of educational technology and project-based learning, can increase student engagement and strengthen concept understanding (Farhin et al., 2023). In addition, collaboration between teachers, students and parents is also important in creating a supportive learning environment. By implementing more constructive and engaging strategies such as*project-based* learning, students' interest and motivation in mathematics can increase, which can affect the improvement of expected learning outcomes.

Project-based learning (PjBL) has become an approach that is often adopted in education, given its positive potential in improving the quality of learning (Wahyuni & Fitriana, 2021). PjBL provides opportunities for students to be actively involved in the learning process through real projects with daily life contexts. *Project Based Learning* not only facilitates the development of practical skills, but also strengthens student motivation which is often a determining factor in educational success (Amin & Romelah, 2024). By placing students in situations that demand collaboration, creativity, and problem solving, PjBL can create a more meaningful and engaging learning experience.

The application of PjBL allows students to link the theory learnt in class with practice in the field, resulting in a better understanding of the concepts taught (Ramadhan & Hindun, 2023). In the process followed, students are encouraged to conduct exploration, research, and reflection that can improve the quality of learning outcomes. According to Ansya (2023), PjBL not only helps students master the subject matter, but also develops critical and collaborative thinking skills. Therefore, PjBL is considered an effective pedagogical strategy in preparing students to face challenges in a changing world.

Primary school students are often in the early stages of understanding abstract concepts, including those in Mathematics, so interactive learning methods, such as Project Based Learning (PjBL), are particularly appropriate. With PjBL, students are given the opportunity to be directly involved in projects that illustrate the real application of the concepts learned, so that the learning process becomes more contextual and meaningful (Rahmat, 2024). The model not only helps students internalise and understand the material better, but also has the potential to increase student motivation and engagement in the learning process, as students feel more connected to what they are learning.

On the other hand, mathematics requires a learning approach that allows students to conduct experiments and observations directly, so that they can understand scientific concepts through practical experience (Musyadad et al., 2019). The Project-Based Learning (PjBL) model provides opportunities for students to engage in activities related to natural phenomena, which not only enriches students' understanding but also enables applied learning. By engaging students in practical activities that demand observation and analysis, PjBL can encourage students' curiosity and engagement in learning mathematics.

Based on preliminary observations conducted at SD Muhammadiyah 5 Porong, the effectiveness of mathematics learning is often not optimal, and students tend to experience difficulties in understanding basic concepts. The observations indicated that the traditional teaching model that focuses more on lectures and assignments is less able to encourage active student involvement. Students appear less motivated and have difficulty in applying the concepts that have been taught. This creates an urgent need to find a more effective and engaging learning approach for students.

The Project-Based Learning (PjBL) model is used as an effort to improve learning outcomes in mathematics. PjBL allows students to engage in contextualised projects, so that students can link theory with practice directly. By involving students in group activities that integrate science mathematics concepts, students can better understand the material in a more enjoyable way by doing meaningful projects. The application of PjBL can not only improve students' academic understanding, but also generate interest and motivation in learning, create a better educational experience and have a positive impact.

Previous research conducted by Ramadianti (2021) and Fitriyani et al. (2023) showed that the Project-Based Learning model had a significant effect on student learning outcomes in mathematics. The current study aims to explore the application of Project-Based Learning (PjBL) model particularly on mathematics learning outcomes of elementary school students of SD Muhammadiyah 5 Porong, by emphasising the aspects of creativity and collaboration in the learning process. The current study will also identify the effect of PjBL on learning outcomes on problem solving. In addition, this study will also analyse how the interaction between students in the project group can affect motivation and engagement in learning.

METHOD

Research Design

The research design was conducted with the aim of analysing the effectiveness of the Project Based Learning (PjBL) model on Mathematics learning outcomes of Primary School students. The population in this study were all grade V students at the school. The population in the class totalled 24 students which will be carried out through two tests (*pre test* and *post test)*.

During the research, data will be collected through *pre and post tests* to measure students' learning outcomes before and after the application of Project Based Learning (PjBL) model. The Pre *test* will be conducted before the PjBL model is applied, in order to obtain an initial picture of students'

learning outcomes of Mathematics concepts. After the learning period is completed, a *post test* will be conducted to evaluate the differences in student learning outcomes and identify how effective the PjBL model can be in influencing the learning outcomes of the subject.

Data Analysis

Data analysis will be conducted using non-parametric statistical methods. The data obtained from the *pretest* and *posttest* will be analysed to determine whether there is a difference between two paired samples. This research data will be tested using the Wilcoxon test using SPSS. With this Wilcoxon test, it can be seen the effectiveness of the PjBL model on students' mathematics learning outcomes.

RESULTS

The following research results present the research data that has been processed by the researcher using the SPSS *software* tool. The following data is obtained from the results of research conducted with two actions, namely *pre test* and *post test*.

Table 1. Normality Test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	,165	24	,092	,946	24	,562
Posttest	,146	24	,200*	,940	24	,167

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results of the shapiro wilk calculation show that the significance value of the pre-test is 0.562 and 0.167 for the posttest. If the sig value> 0.05 then the research data is normally distributed. if the sig value <0.05 then the research data is not normally distributed. Thus, it can be concluded that the pre-test and post-test research data are normally distributed because the pre-test sig value is 0.562> 0.05 and the post-test sig value is 0.167> 0.05. Then the data analysis test will be carried out with the paired sample test.

Tabel 3. ***Paired Samples Test***

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Pre-test Kelas V Post-test Kelas V	-11.12500	6.54292	1.33557	-13.88783	-8.36217	-8.330	23	.000

Based on the presentation of the results of the t test for paired samples comparing the difference in scores between the *pretest* and *posttest* in class V. The mean difference between the *pretest* and posttest was -11.125 with a standard deviation of 6.543 and a mean standard error of 1.336. The 95% confidence interval for the difference ranged from -13.888 to -8.362 indicating that the difference in scores between the *pretest* and *posttest* was significant. The t value obtained was -8,330 with 23 degrees of freedom (df), and the significance result (Sig. 2-tailed) showed a value of 0.000. Because the significance value is far below the alpha level of 0.05. So it can be concluded that there is a significant difference between the *pretest* and *posttest* scores, which indicates that the application of the *Project Based Learning* (PjBL) model used succeeded in improving the mathematics learning outcomes of grade V students at SD Muhammadiyah Porong. The value of 0.000 indicates that the possibility of these results occurring by chance is very small, so these findings can be considered valid and relevant in the context of the research conducted.

DISCUSSION

The application of innovative learning methods in basic education has an urgency in improving

student learning outcomes, especially in mathematics subjects which are often considered difficult and challenging by many students. A study conducted by Sholeh et al. (2024), showed that the *Project Based Learning* (PjBL) model is an effective approach to increase students' motivation and interest in learning mathematics. By promoting project-based learning, PjBL allows students to be actively involved in the learning process, so as to facilitate a good understanding of mathematical concepts. *Project Based Learning* (PjBL) models not only encourage creativity and collaboration among students, but also present real contexts that can increase the relevance of subject matter in everyday life.

Based on the results of the t-test for paired samples, there was a significant difference between the *pretest* and *posttest* scores of elementary school students of SD Muhammadiyah 5 Porong, with an average difference of -11.125 indicating that the *posttest* score was higher. The standard deviation of 6.543 and the standard error of the mean of 1.336 indicated the change, thus showing a good effect of the implementation of *Project Based Learning* (PjBL) on students' understanding of mathematics concepts. The 95% confidence interval for the difference in scores ranged from -13.888 to -8.362, indicating that the changes were not coincidental, but the result of a systematic learning model. The analysis yielded a t-value of -8.330 with 23 degrees of freedom and a significance of 0.000, well below the alpha level of 0.05, indicating that the null hypothesis can be
rejected. Thus, PjBL significantly improved the mathematics learning outcomes of Muhammadiyah 5 Porong primary school students.

Through the *Project Based Learning* (PjBL) model, students are given the opportunity to collaborate in completing projects that are closely related to the mathematics material being studied, which not only serves as a tool for applying theory, but also as a means to encourage critical and creative thinking in problem solving. The projects facilitate collaborative activities that strengthen social interaction and constructive communication among students, creating a dynamic and fun learning environment (Fitriana et al., 2024). Students not only acquire mathematical knowledge, but also gain social skills, such as cooperation and communication that are indispensable in everyday life. The application of PjBL in education as a foundation for the development of students' cognitive, psychomotor and affective skills, in preparation for future challenges in both academic and social contexts (Almuzhir, 2022).

The project that students do is to make a project related to fraction material with the following syntax:

1. Preparing Questions
   Students determine the basic question that will guide the project and explore the important aspects of fraction material.

Figure 1. Preparing Questions.

2. Make project design
   Students design a way to answer the basic question, including the methods and sources to be used.

Figure 2. Make project design.

3. Develop scheduling
   Students organise a schedule for each stage of the project, ensuring each step has an appropriate time allocation.

Figure 3. Develop scheduling

4. Monitor project progress
   Teachers and students monitor the progress of the project through regular discussions and progress reports, providing opportunities for reflection and adjustment.

Figure 4. Monitor project progress

5. Outcome assessment
   The teacher assesses the final project results, evaluating students' understanding of fractions as well as their ability to present the results.

Figure 5. Outcome assesment

6. Experience evaluation
   Students reflect on the process they went through, evaluating the learning experience and the skills they have developed throughout the project.

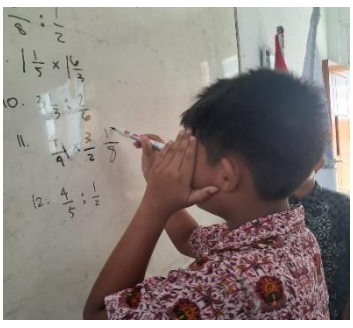

Figure 6. Experience evaluation

Thus, the application of the *Project Based Learning* (PjBL) model in the context of mathematics learning not only has an impact on improving students' academic results, but also has an impact on the development of other skills, such as cooperation, creativity and problem-solving abilities. The implementation of projects demands that students engage in a more active and contextualised learning process, which helps in understanding and internalising mathematical concepts that are more applicable. This approach is in line with the principles of constructivist education which emphasises the importance of student involvement as active agents in the learning process, where students do not only passively receive information, but also build knowledge through direct experience and collaboration with their peers (Gunanto, 2021). Thus, PjBL serves not only as a teaching method, but also as a strategy that promotes better learning in mathematics education.

CONCLUSIONS

Based on the results of the researcher's analysis of the Effectiveness of the *Project Based Learning* (PjBL) Model on Mathematics Learning Outcomes of Primary School Students at SD Muhammadiyah 5 porong, that the *pretest* and *posttest* scores of grade V students showed a significant increase in mathematics learning outcomes. The statistical test results show that there is a significant difference between the pretest and posttest scores with an average difference of -11.125. The significance value of 0.000 which is smaller than 0.05 indicates that the application of the Project Based Learning (PjBL) model has a significant effect on the mathematics learning outcomes of grade V elementary school students. Through PjBL, students not only experienced an increase in grades, with an average *posttest* difference, but also developed other skills such as cooperation, creativity and problem-solving ability. PjBL allows elementary school students to collaborate on a given project with the subject matter, thus supporting critical thinking and providing real

context for the mathematical concepts being taught. In addition, PjBL creates a dynamic and fun learning environment, in accordance with the principles of constructivist education which emphasises the active role of students in the learning process.

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