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The Effect of the Project-Based Learning (PjBL) Model on the Scientific Literacy Skills of Elementary School Students in Science Learning

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Abstract

This study is motivated by the low scientific literacy level of elementary school students in Indonesia and the tendency of science learning to be highly teacher-centered. This study aims to comprehensively examine the effect of implementing the Project Based Learning (PjBL) model on improving the scientific literacy skills of fifth-grade students in science learning. The method used was a quasi-experiment with a Nonequivalent Control Group Design. The sample was selected using purposive sampling, consisting of an experimental class (N=30) and a control class (N=30). Data were collected using a science literacy test consisting of 20 items that had been tested for validity and reliability. The results showed that the post-test average of the experimental class reached 83.20, higher than the control class which obtained 65.60. The improvement (N-Gain) in the experimental class was moderate approaching high (0.67), which significantly outperformed the control class (0.35). Hypothesis testing (t-Test) resulted in a significance value of 0.000 < 0.05, concluding that the application of the PjBL model has a positive and significant effect on improving students' science literacy.

Keywords: Elementary School; PjBL; Science Learning; Scientific Literacy.

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INTRODUCTION

Scientific literacy is a fundamental skill that 21st-century students must possess to solve everyday problems scientifically (Bell, 2010; Afriana, Permanasari, & Fitriani, 2016). However, based on the Program for International Student Assessment (PISA) survey results released by the OECD, the scientific literacy scores of Indonesian students consistently fall into the low category (OECD, 2019; Bagasta, Susanti, & Suwondo, 2018). This low achievement is caused by a gap between global competency demands and science learning practices in schools, which remain dominated by textual and teacher-centered approaches (Winata, Cacik, & Seftia, 2018; Sumartati, 2010).

This condition aligns with preliminary observations conducted in the fifth grade of Embun Pagi Islamic School. In learning materials that require an understanding of body mechanics, such as the muscle and movement system, students are generally directed to memorize concepts rather than engaging in scientific investigations. Consequently, students struggle to design investigations and interpret scientific data, which are the main indicators in assessing scientific literacy (Gormally, Brickman, & Lutz, 2012; OECD, 2019).

To bridge this research gap, an innovative and student-centered learning intervention is required. The Project-Based Learning (PjBL) model is proposed as an alternative solution because its learning syntax aligns with scientific literacy indicators (Abidin, 2014). PjBL facilitates students in constructing knowledge through the investigation of authentic problems and the creation of tangible products (Bell, 2010; Afriana et al., 2016). While various previous studies have proven the effectiveness of PjBL, the novelty of this research lies in the modification of a mechanical arm construction project to examine the antagonistic muscle system (biceps and triceps), as well as the specific adaptation of PISA indicators to the elementary school level.

Based on this background, this study aims to determine and empirically analyze the significant difference in the improvement of scientific literacy skills between students who receive PjBL-based instruction compared to those receiving conventional instruction.

METHODS

This study employed a quantitative approach utilizing a quasi-experimental method. The applied research design was the nonequivalent control group design, in which the experimental group received the treatment (PjBL model) while the control group used the conventional model. The research population included all fifth-grade students at Embun Pagi Islamic School. Sampling was conducted using a purposive sampling technique, resulting in two groups: class V-A as the

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experimental group (N = 30) and class V-B as the control group (N = 30). The data collection instrument consisted of 20 multiple-choice scientific literacy test items developed from the 2022 PISA indicators (explaining phenomena, designing investigations, and interpreting data). This instrument had been tested for feasibility and demonstrated a very high level of reliability (Cronbach's Alpha = 0.972). Data were analyzed using descriptive and inferential statistics. Prerequisite tests included the normality test (Shapiro-Wilk) and the homogeneity test (Levene's Test). The improvement in scientific literacy skills was measured using the Normalized Gain (N-Gain) with the standard formula:

$$g = \frac{Posttest\ Score - \ Pretest\ Score}{Maximum\ Ideal\ Score - \ Pretest\ Score}$$

Hypothesis testing was performed using the Independent Sample t-Test with a significance level of 0.05.

RESULTS AND DISCUSSION

Results

Based on the prerequisite tests conducted, the pre-test and post-test data of both groups were normally distributed (Sig. > 0.05) and had homogeneous variances (Sig. > 0.05), thus meeting the requirements for testing using parametric statistics. The descriptive analysis of the mean test scores is presented in Table 1.

Table 1. Descriptive Analysis of Pre-test and Post-test Data

Class	Test Type	Minimum Score	Maximum Score	Mean	Standard Deviation
Experimental (PjBL)	Pre-test	32.00	68.00	8.40	10.25
	Post-test	68.00	96.00	3.20	7.45
Control (Conventional)	Pre-test	32.00	64.00	7.20	9.80
	Post-test	52.00	84.00	5.60	8.15

Table 1 shows that the initial abilities (pre-test) of both groups were relatively equal and fell into the low category. After receiving the treatment, the experimental group experienced a

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highly drastic surge in the mean score (83.20) compared to the control group (65.60).

To eliminate the bias of initial score guessing and measure genuine improvement, an N-Gain test was conducted, the results of which are presented in Table 2.

Table 2. Results of N-Gain Average Calculation

Class	Average N-Gain Score	N-Gain Percentage	Category
Experimental (PjBL)	**0.67**	**67.4%**	**Moderate (Approaching High)**
Control (Conventional)	**0.35**	**34.8%**	**Moderate (Approaching Low)**

Furthermore, the results of the Independent Sample t-Test on the N-Gain scores showed a t-value of 5.842 with a Sig. (2-tailed) probability of 0.000. Because 0.000 < 0.05, H0 was rejected and Ha was accepted, proving a significant difference in improvement between the two classes.

DISCUSSION

The findings of this study confirm that the PjBL model is far more effective than the conventional model in fostering the scientific literacy skills of elementary students. The superiority of the experimental class with an N-Gain of 0.67 is inseparable from the PjBL syntax, which integrates directly with the PISA scientific literacy indicators.

First, the phase of determining fundamental questions (Syntax 1) regarding how hard bones can bend at the elbow joint successfully provoked students' curiosity. This activity structuredly trained students on the first PISA indicator: explaining natural phenomena rationally. Students no longer passively received theories but were encouraged to formulate their initial scientific hypotheses.

Second, the process from designing to scheduling the mechanical arm project (Syntax 2, 3, and 4) facilitated the PISA indicator regarding designing scientific investigations. When students had to visualize the arm using cardboard, split pins (as hinge joints), and balloons/rubber bands (as antagonistic muscles), they directly experienced contextual and hands-on learning. According to Winata et al. (2018), hands-on activities mature students' understanding because they are directly exposed to scientific procedures and trial and error.

Third, the phase of testing the project results and evaluation (Syntax 5 and 6) culminated

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in strengthening the indicator of scientific data interpretation. As students tested the mechanics of their project and recorded the changes in the balloon's tension ("muscle") on the Worksheet, they transformed visual empirical data into the conclusion that muscles work in pairs through the process of contraction and relaxation. Meanwhile, in the control class, the N-Gain stagnated at 0.35 due to textual learning. Students only copied notes and listened to lectures; thus, when faced with a problem-solving-based scientific literacy evaluation instrument, their cognition had not been trained to interpret scientific data without accompanying text.

CONCLUSION AND RECOMMENDATIONS

There is a significant difference in the improvement of scientific literacy skills between students using the PjBL model and those using the conventional model. The application of the PjBL model provides a positive and significant impact, with the experimental class achieving an N-Gain of 0.67, far outperforming the control class, which only obtained 0.35. The PjBL syntax has been proven capable of reconstructing students' scientific reasoning in alignment with PISA indicators, specifically the ability to explain phenomena, design investigations, and interpret scientific data tangibly.

For teachers, it is recommended to implement PjBL as an applicable student-centered model alternative; however, careful time management during the project construction phase must be taken into consideration. For future researchers, it is suggested to expand the scope of research variables, such as critical thinking skills and collaborative motivation across different science topics, to enrich the repertoire of educational research.

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