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The impact of problem-based learning on motivation and mathematics outcome for sixth-grade students

Ronaldo Kho [1,*], Titi Solihati [2], Happy Lumbantobing [1]

[1] Cenderawasih University, Jayapura, Papua, Indonesia
[2] SD Inpres Nawapiri Timika, Mimika, Central Papua, Indonesia

[*] Correspondence: ronaldoankho@gmail.com

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Abstract

Numerous studies have demonstrated that the implementation of problem-based learning (PBL) can enhance student motivation and learning outcomes. However, the integration of contextual media in these instructional activities remains limited. This research aims to investigate the impact of using PBL with contextual media on student outcomes, compare the differences in mathematics achievement between students taught through PBL with contextual media and those taught through conventional methods, and assess variations in student motivation between these two instructional approaches. A quasi-experimental design with a non-equivalent pretest-posttest control group was employed in this study. The participants consisted of 60 sixth-grade students, divided into an experimental group (taught using PBL with contextual media) and a control group (taught using conventional methods). Data were collected through learning motivation questionnaires and objective mathematics tests, with data analysis conducted using normalized gain scores (N-Gain) and t-tests. The results indicated significant improvements in student outcomes when taught using PBL with contextual media. Additionally, there was a marked difference in mathematics achievement between the experimental and control groups, as well as differences in student motivation between the two instructional methods. These findings suggest that implementing PBL with contextual media presents a promising strategy for enhancing both student motivation and mathematics learning outcomes.

Keywords: Contextual Media, Learning outcomes, Motivation, Problem-Based Learning, Sixth-grade students

Introduction

Educational systems globally strive to develop individuals who are capable of critical thinking and applying acquired knowledge effectively within society (Karatsiori, 2023; Raj et al., 2022; Yang, 2024). A fundamental aspect of this endeavor involves the methodologies employed in teaching and learning. For knowledge to be effectively transmitted, educators must comprehend students' cognitive processes and facilitate the construction of a deep understanding and meaningful interactions within the classroom (Chew & Cerbin, 2021; Trinidad, 2020; Zambrano & Campuzano, 2020). Additionally, it is imperative to utilize dynamic teaching methods and strategies to address the diverse needs of learners (Farmer et al., 2019; Kim et al., 2019; Szabo et al., 2020). Beena Rosy (2024) emphasizes that educators should adapt their pedagogical approaches and embrace innovative methodologies to enhance teaching and learning outcomes.

Elementary schools serve as foundational educational institutions where students acquire basic knowledge, forming the groundwork for more advanced studies. Mathematics, a critical subject at this level, demands thorough understanding and proficiency (Chand et al., 2021; Dolapcioglu & Doğanay, 2022; Setiana et al., 2021; Tanujaya et al., 2017). Teaching mathematics in elementary schools is crucial for developing students' logical, critical, analytical, and creative thinking skills, essential for problem-solving both in mathematics and everyday life (Dolapcioglu & Doğanay, 2022; Kurniawati et al., 2022; Yayuk et al., 2020). Mathematics involves abstract concepts, facts, and principles (Kenedi et al., 2019), which are often challenging for students, as they may perceive the subject as intimidating, uninteresting, and difficult (Ismail et al., 2022; Mazana et al., 2018; Suren & Ali Kandemir, 2020). Consequently, these perceptions can lead to difficulties in learning, misconceptions, problem-solving errors, decreased self-confidence, and heightened anxiety in mathematics classrooms (Namkung & Bricko, 2021; Stein et al., 2020; Sutarto, 2022; Jarrah et al., 2022; Rahayu et al., 2022; Li et al., 2021; Luttenberger et al., 2018). These challenges ultimately diminish students' motivation to learn (Nurlaily et al., 2019).

Motivation, a driving force behind individual effort, encompasses the emotions associated with achieving goals and experiencing fulfillment. It plays a crucial role in determining the intensity of students' learning efforts, ensuring continuity in their learning process, and achieving the desired outcomes (Nazirwan et al., 2024). Motivation is generally categorized into two types: intrinsic, driven by internal needs, and extrinsic, influenced by external rewards. High motivation levels are associated with active engagement in learning, while low motivation can lead to a lack of enthusiasm, negatively affecting learning outcomes (Rosmawati et al., 2023).

In education, the teaching-learning process is a critical area of focus. Students are more likely to engage with mathematics if the teacher can create a positive learning environment where concepts are clearly presented and retained in long-term memory (Ayuwanti et al., 2021). Achieving this requires a competent learning strategy that caters to students' thought processes, fostering meaningful interactions and effective knowledge transmission. Teachers must employ dynamic methods and strategies that engage diverse learners (Szabo et al., 2020; Vale & Barbosa, 2023). Selecting an appropriate learning model that aligns with the students' context and learning environment is essential for fostering active, interactive, and creative learning. Such models should enhance students' analytical processes, critical thinking skills, and the application of knowledge in real-life situations. Ghani et al. (2021) supports this view, advocating for the adaptation of teaching strategies and the incorporation of innovative methods to improve educational outcomes.

SD Inpres Nawaripi, an elementary school in Nawaripi Village, Wania District, Mimika Regency, serves students from the first through sixth grades. In this school, students frequently encounter difficulties in learning mathematics. Interviews with a sixth-grade teacher revealed issues such as students' lack of motivation, difficulties in understanding lesson material, reluctance to ask questions, and inattention during lessons. Classroom observations further revealed that traditional teaching methods were predominantly used, corroborating findings by Yani et al. (2023), who reported similar challenges. These problems can diminish students' motivation and result in lower mathematics achievement.

Several factors contribute to students' underperformance in mathematics. Surveys indicate that many teachers still rely on traditional teaching methods, which do not foster knowledge-rich environments or encourage independent thinking and problem-solving. Consequently, students struggle to apply learned concepts to practical scenarios, often resorting to rote memorization of formulas rather than developing problem-solving skills. Additionally, teachers may not adequately support students in becoming independent problem solvers. However, these issues can be mitigated through the implementation of innovative learning models. Problem-based learning (PBL) is one such approach that can effectively address these challenges by making complex concepts more accessible and engaging (Ghani et al., 2021).

PBL is an educational approach designed to equip students with the skills necessary to tackle complex, real-world problems (Akcay & Benek, 2024). It emphasizes the development of critical thinking, problem-solving abilities, and self-directed learning through a learner-centered methodology that integrates theory and practice (Tawfik et al., 2021). PBL has been shown to increase students' motivation and improve academic outcomes (Abdalla et al., 2021; Smith et al., 2022). By placing students at the center of the learning process, PBL encourages active engagement, collaboration, and the application of various skills and concepts in solving mathematical problems. Through this approach, students not only enhance their motivation and engagement but also apply mathematical knowledge to real-world contexts, critically evaluate their learning processes, and develop essential critical thinking skills. PBL, as a scientific problem-solving approach, is expected to be more effective than traditional methods, positively impacting students' learning outcomes (Ali, 2019; Yew & Goh, 2016).

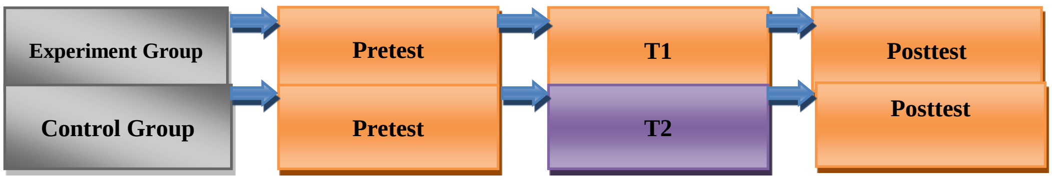
According to Piaget, elementary school students are in the concrete operational stage, where they tend to think more concretely than abstractly. Therefore, mathematics instruction at this level benefits from the use of concrete materials. The effectiveness of PBL can be further enhanced by incorporating appropriate learning media that capture students' attention and boost their motivation. Contextual media, in particular, is well-suited for elementary students, facilitating a more engaging and meaningful learning experience (Fitria et al., 2021). This type of media encourages active participation, provides authentic learning experiences, and fosters enthusiasm for learning (Vera, 2022). Contextual media aids in clarifying abstract mathematical concepts, promoting deeper understanding and retention (Solehah et al., 2024). With the integration of contextual media, PBL can create an enjoyable and effective learning environment, enabling students to explore mathematical concepts more thoroughly and develop higher motivation, ultimately leading to improved learning outcomes.

Research has consistently demonstrated that PBL, coupled with enhanced motivation, can significantly improve students' mathematics outcomes (Safitri et al., 2023). The PBL model has been shown to positively impact learning across cognitive, psychomotor, and affective domains (Nurlaily et al., 2018). The role of the teacher is also crucial in implementing PBL to foster student competence and drive better academic results (Arif et al., 2024). Finally, this study, conducted with sixth-grade students at SD Inpres Nawaripi, aims to investigate the improvement in student outcomes taught using PBL with contextual media, the differences in students' mathematics outcomes between PBL with contextual media and conventional learning, and the differences in students' motivation when taught using PBL with contextual media compared to conventional teaching methods.

Methods

This quasi-experimental study was designed to establish a causal relationship between the experimental and control groups through the application of a non-equivalent pretest-posttest control group design (Figure 1). The research was conducted with sixth-grade students at SD Inpres Nawaripi Timika, located in the Mimika Regency. The study population comprised three classes, one of which was used for instrument testing, while the remaining two classes were selected for sampling through random assignment, resulting in a total of 60 participants. These participants were evenly divided into two groups: 30 students in the control group and 30 students in the experimental group.

The research was executed in three distinct stages. The first stage, the preparation phase, involved conducting a field study, including school observations. The second stage, the implementation phase, encompassed the administration of the research, beginning with a pre-test. Finally, the third stage, the evaluation phase, involved conducting a post-test to assess the impact of the Problem-Based Learning (PBL) model on the participants.



Note:
T_1 = Experimental group
T_2 = Control group

Figure 1. Nonequivalent Pretest-Posttest Control Grup Design

Data collection for this study employed two primary methods: tests and questionnaires. The test was designed to evaluate students' mathematical performance through five open-ended questions. The questionnaire, comprising 17 valid items measured on a Likert scale, was developed to gauge student motivation. Data collection occurred in both the pre-research and research phases. During the pre-research phase, data was gathered through interviews and observations of the ongoing learning process. The experimental phase involved administering a pretest before the intervention and a posttest following the intervention.

Data analysis was conducted using normalized gain scores (N-Gain) (Hake, 1998) and t-tests. The statistical analysis was performed using the SPSS 25 software for Windows. Prior to hypothesis testing, the data were subjected to normality and homogeneity tests. The t-test was then applied to evaluate the hypothesis, contingent on the data being normally distributed and the group variances being comparable. In this study, the learning outcome was treated as the independent variable, while the PBL model and student motivation were considered dependent variables.

Results and Discussion

Results

The mathematics outcomes data consist of pretest and posttest results from both the experimental and control groups. The pretest data provide a baseline measure of the students' mathematical abilities in both groups prior to the implementation of the Problem-Based Learning (PBL) intervention. In contrast, the posttest data represent the students' mathematical performance following the intervention. The results pertaining to the students' critical thinking skills are summarized in Table 1.

Table 1. Pure Data on Mathematics Outcomes

Description	Experimental Group (n = 30)		Control group (n = 30)	
	Pretest	Posttest	Pretest	Posttest
Mean	29.90	75.30	30.27	60.47
Standard Deviation	4.467	7.502	6.633	7.833
Variance	19.955	56.286	43.995	61.361
Minimal	19.00	63.00	13.00	38.00
Maximal	38.00	94.00	38.00	81.00

Table 1 presents the pretest and posttest scores for both the experimental and control groups. The experimental group had a mean pretest score of 29.90, with individual scores ranging from 19.00 to 38.00. In comparison, the control group’s mean pretest score was 30.27, with scores ranging from 13.00 to 38.00. Following the intervention, the experimental group’s mean posttest score increased to 75.30, with scores spanning from 63.00 to 94.00. Conversely, the control group’s mean posttest score was 60.47, with scores ranging from 38.00 to 81.00.

The pretest-posttest assessment results indicate a notable increase in the experimental group’s mean mathematics outcomes, which rose from 29.90 to 75.30. In contrast, the control group’s mean mathematics outcomes score increased from 30.27 to 60.47. A comparison of the score improvements between the experimental and control groups reveals that the experimental group experienced a more significant enhancement in mathematics outcomes compared to the control group.

Table 2 displays the N-Gain values for the mathematics outcomes of both groups, as calculated using SPSS 25 for Windows. According to the data presented in Table 2, the mean N-Gain for the experimental group was 64.63, with individual scores ranging from 45.45 to 90.91. In contrast, the control group had a mean N-Gain of 43.16, with scores varying from 28.57 to 72.73. A comparison of the mean N-Gain scores between the two groups indicates that the experimental group demonstrated a more substantial improvement in mathematics outcomes compared to the control group.

Table 2. Output N-Gain Mathematics Outcomes of Experimental and Control Groups

Description	Experimental Group (n = 30)		Control group (n = 30)	
	N-Gain Score	N-Gain (%)	N-Gain Score	N-Gain (%)
Mean	0.6463	64.63	0.4316	43.16
Minimal	0.4545	45.45	0.2857	28.57
Maximal	0.9091	90.91	0.7273	72.73

Figure 2 depicts the N-Gain values for the mathematics outcomes of both the experimental and control groups.

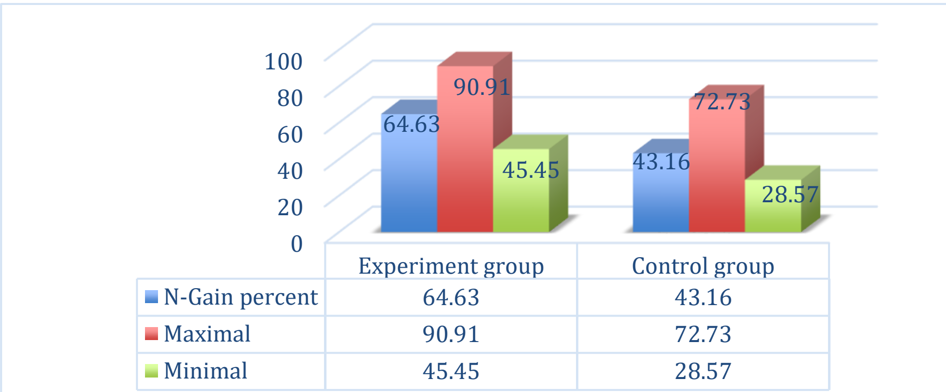


Figure 2. Comparing Two Groups

Utilizing SPSS 25, determine the N-Gain score analysis results, as indicated in Table 3.

Table 3. The Results of the *N-Gain Score* of Experiment and Control Class

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Outcome	N-Gain Experiment (PBL)	30	64,5337	10,87470	1,98544
	N-Gain Control (Conventional)	30	43,1560	10,42193	1,90278

The average N-Gain percentage for the experimental class is 64.53%, while the average N-Gain percentage for the control class is 43.16%, as detailed in Table 3. The N-Gain analysis indicates that the experimental class, which employed Problem-Based Learning (PBL) with contextual media, falls into the "effective" category. In contrast, the control class, which utilized traditional teaching methods, is classified as "less effective." This suggests that the PBL approach with contextual media resulted in significant improvements in student outcomes for the sixth-grade students at SD Inpres Nawaripi.

To validate these findings, normality and homogeneity tests are necessary prerequisites for conducting the t-test. The normality test assesses whether the research subjects are drawn from a normally distributed population. For this purpose, the Kolmogorov-Smirnov method was applied using SPSS 25 for Windows. The hypothesis for the normality test is as follows.

H_o: Data is normally distributed.
H_a: Data is not normally distributed.

A significance value greater than the specified alpha level ($\alpha > 0.05$) indicates that the normality hypothesis is accepted, suggesting that the data are normally distributed. Conversely, a significance value less than the specified alpha level ($\alpha < 0.05$) leads to the rejection of the normality hypothesis, indicating that the data are not normally distributed. The results of the normality test for the N-Gain scores in both the control and experimental classes are presented in Table 4.

Table 4. Normalcy Tests

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Outcome	N-Gain Experiment (PBL)	,134	30	,179	,966	30	,441
	N-Gain Control (Conventional)	,143	30	,121	,933	30	,059

a. Lilliefors Significance Correction

According to the results presented in Table 4, the significance values for the N-Gain scores in both the control and experimental groups exceed the specified alpha level, as determined by the Kolmogorov-Smirnov and Shapiro-Wilk tests. Consequently, the null hypothesis (H_0) is accepted, indicating that the data are normally distributed.

The homogeneity test aims to determine whether the participants in the study are drawn from populations with homogeneous or heterogeneous variances. To assess this, Levene's test was employed using SPSS 25 for Windows. The hypothesis for the homogeneity test is as follows:

H_o: The variances of the variable are equal or homogenous.
H_a: The variances of the variable are not equal or heterogeneous.

The homogeneity test results are interpreted as follows: if the significance value obtained is greater than the specified alpha level ($\alpha > 0.05$), the null hypothesis is accepted, indicating that the variances of the groups are homogeneous. Conversely, if the significance value is less than the specified alpha level ($\alpha < 0.05$), the null hypothesis is rejected, suggesting that the variances are not homogeneous. The results of the homogeneity test for the N-Gain scores in both the control and experimental groups are presented in Table 5.

Table 5. Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Outcome	Based on Mean	,002	1	58	,964
	Based on Median	,003	1	58	,957
	Based on the Median and with adjusted df	,003	1	57,691	,957
	Based on trimmed mean	,004	1	58	,951

Table 5 indicates that the significance values for the N-Gain scores in mathematics outcomes, derived from the pretest for both the experimental and control groups, exceed the specified alpha level. Therefore, the null hypothesis (H_o) is accepted, suggesting that the variances of the variables are equal (homogeneous). Consequently, the first hypothesis will be tested using a t-test, conducted with SPSS 25 for Windows.

H_o: $\mu A_1 = \mu A_2$
(There is no significant difference in students' mathematics outcomes between PBL with contextual media and conventional learning).
H_a: $\mu A_1 \neq \mu A_2$
(There is a significant difference in students' mathematics outcomes between PBL with contextual media and conventional learning).

The null hypothesis (H_o) is rejected if the obtained significance value (p-value) is less than 0.05. The results of the t-test analysis for the posttest scores of mathematics outcomes are presented in Table 6.

Table 6. Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Outcome	Equal variances assumed	,002	,964	7,774	58	,000	21,37767	2,75000	15,87293	26,88240
	Equal variances not assumed			7,774	57,895	,000	21,37767	2,75000	15,87272	26,88261

Table 6 presents the output of the Independent Samples t-test, which shows a significance value of 0.000, indicating a value less than 0.05. This result suggests that there is a significant difference in learning outcomes between students in the experimental class, who were taught using Problem-Based Learning (PBL) with contextual media, and those in the control group, who received traditional instruction. Therefore, it can be concluded that there is a significant difference in mathematics outcomes between the PBL with contextual media and conventional teaching methods for sixth-grade students at SD Inpres Nawaripi.

For the motivation data, normality and homogeneity tests are prerequisites for conducting the t-test. The normality test assesses whether the research subjects are drawn from a normally distributed population. This is achieved using the Kolmogorov-Smirnov method, applied through SPSS 25 for Windows. The hypothesis for measuring normality is as follows:

H_o: Data is normally distributed.
H_a: Data is not normally distributed.

If the significance value obtained is greater than the specified alpha level ($\alpha > 0.05$), the null hypothesis is accepted, indicating that the data are normally distributed. Conversely, if the significance value is less than the specified alpha level ($\alpha < 0.05$), the null hypothesis is rejected, suggesting that the data are not normally distributed. The results of the normality test for motivation data in both the control and experimental classes are presented in Table 7.

Table 7. The Result of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Motivation	Experiment (Motivation)	,121	30	,200*	,963	30	,373
	Control (Motivation)	,075	30	,200*	,970	30	,534

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 7 shows that the significance values for motivation data in both the control and experimental groups exceed the specified alpha level, as determined by the Kolmogorov-Smirnov and Shapiro-Wilk tests. Consequently, the null hypothesis (H_0) is accepted, indicating that the data are normally distributed.

The homogeneity test aims to determine whether the participants in the study come from populations with homogeneous or heterogeneous variances. This test was conducted using Levene's test in SPSS 25 for Windows. The hypothesis for assessing homogeneity is as follows:

H_o: The variances of the variable are equal or homogenous.
H_a: The variances of the variable are not equal or heterogeneous.

If the significance value obtained is greater than the specified alpha level ($\alpha > 0.05$), the null hypothesis is accepted, indicating that the variances are homogeneous. Conversely, if the significance value is less than the specified alpha level ($\alpha < 0.05$), the null hypothesis is rejected, suggesting that the variances are not homogeneous. The results of the homogeneity test for motivation data in both the control and experimental groups are presented in Table 8.

Table 8. The Results of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Motivation	Based on Mean	3,161	1	58	,081
	Based on Median	3,074	1	58	,085
	Based on Median and with adjusted df	3,074	1	52,670	,085
	Based on trimmed mean	3,132	1	58	,082

Table 8 indicates that the significance values for the N-Gain scores in mathematics outcomes, derived from the pretest for both the experimental and control groups, exceed the specified alpha level. Consequently, the null hypothesis (H_0) is accepted, suggesting that the variances of the variables are equal (homogeneous).

The second hypothesis will be tested using a t-test conducted with SPSS 25 for Windows. The null hypothesis (H_0) is rejected if the obtained significance value (p-value) is less than 0.05. The results of the t-test analysis for the posttest scores of critical thinking skills are presented in Table 9.

H_o: $\mu A_1 = \mu A_2$
(There is no significant difference in students' motivation between PBL with contextual media and conventional learning).
H_a: $\mu A_1 \neq \mu A_2$
(There is a significant difference in students' motivation between PBL with contextual media and conventional learning).

Table 9 presents the output of the Independent Samples t-test, which shows a significance value of 0.000, indicating a value less than 0.05. This result signifies a significant difference in student motivation between the Problem-Based Learning (PBL) approach with contextual media and conventional learning methods. Thus, it can be concluded that there is a notable difference in student motivation between the PBL with contextual media and conventional teaching methods for sixth-grade students at SD Inpres Nawaripi.

Table 9. The Results of Independent Sample t-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Motivation	Equal variances assumed	3,161	,081	25,734	58	,000	23,900	,929	22,041	25,759
	Equal variances not assumed			25,734	52,143	,000	23,900	,929	22,036	25,764

Discussion

The analysis of the data reveals that implementing Problem-Based Learning (PBL) with contextual media significantly enhances mathematics outcomes for sixth-grade students at SD Inpres Nawaripi. The results suggest that collaborative group work enables students to articulate their understanding and opinions based on their prior knowledge of the problem presented by the teacher. These discussions are facilitated by the diverse knowledge each student brings, which is derived from various sources such as reading, listening, observing, or personal experiences. These findings corroborate those of previous research by Bara and Xhomara (2020).

The study also indicates that students engaged in PBL with contextual media exhibit higher levels of motivation compared to those in conventional learning environments. In the PBL approach, students are tasked with solving problems presented in worksheets by relating them to real-life situations. They are responsible for ensuring that all group members understand the work, which involves clarifying issues, employing group problem-solving techniques, gathering and sharing information, discussing solutions, and presenting their findings. This collaborative approach ensures that each member contributes to the group's efforts. These results are consistent with previous studies by Abramovich et al. (2019) and Suren and Ali Kandemir (2020).

PBL with contextual media effectively engages students by transforming everyday problems into sources of curiosity, thereby making learning more meaningful. The context-based nature of PBL provides teachers with a relevant framework for instruction, enhancing the learning experience. The improved motivation observed in PBL contexts, compared to conventional methods, is attributed to the engaging and enjoyable learning environment it fosters. As noted by Abramovich et al. (2019) and Mutodi et al. (2023), PBL facilitates contextual learning by connecting educational content to real-world phenomena, empowering students to take ownership of their learning.

Conclusion

The study demonstrates that sixth-grade students at SD Inpres Nawaripi experienced significant improvements in learning outcomes when taught using Problem-Based Learning (PBL) integrated with contextual media. The results indicate that students exposed to PBL achieved superior performance in mathematics compared to those instructed via conventional teaching methods. This finding highlights the substantial effect of PBL with contextual media on enhancing students' mathematical proficiency. Additionally, students in the PBL group exhibited higher motivation levels compared to their counterparts in traditional learning settings.

In light of these findings, it is recommended that educators enhance the quality and frequency of their collaborative activities within the Teachers Working Group, emphasizing the effective implementation of the PBL model. School principals should actively support this shift by providing professional development opportunities, such as workshops or in-house training, to facilitate the adoption of innovative teaching methodologies like PBL.

Further research is necessary to broaden the sample to include both public and private elementary schools within the Mimika Regency. Additionally, comparative studies investigating the impact of problem-based learning relative to other instructional models are warranted to advance and refine educational practices.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. Furthermore, all ethical considerations, including issues related to plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies, have been thoroughly addressed by the authors.

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