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Effectiveness of the PBL model on mathematics learning to cultivate mathematical literacy of elementary school students

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Abstract
This study aims to determine the effectiveness of the Problem-Based Learning model on mathematics learning to instill mathematical literacy in elementary school students. Quasi Experiment was chosen as the type of this research. The research population was the 5th-grade students at SD Muhammadiyah 08 Cilacap, with the research sample consisting of two classes, namely 5A and 5B. The instruments used are test and non-test instruments. Hypothesis testing was carried out using the independent sample t-test and paired sample t-test. The average score on the pretest before the treatment was 59.7 in class 5A and 55.95 in class 5B. The average pretest score in class 5A was 66.6, and 62.15 in class 5B. The post-test average score was 77.7 in class 5A and 91.8 in class 5B. The study results show that the PBL model influences the mathematical literacy of elementary school students and increases students' learning outcomes.

INTRODUCTION

Mathematics learning in elementary schools is generally directed at achieving standards of students' basic competencies (Nasaruddin, 2013) so that students are able and skilled in applying mathematics (Fuadi et al., 2016). However, mathematics learning should continue. Mathematics learning should increase students' logical thinking. Logical thinking will help students in overcoming the problems they face in everyday life (Mawaddah, 2017; Rachmantika & Wardono, 2019). In addition, mathematics education is also aimed at improving reasoning skills, critical thinking, and systematic and creative (Sinaga, 2018). However, the facts on the ground show that mathematics learning in elementary schools is still considered difficult and frightening by students (Madyaratri et al., 2019; Siregar, 2017; Wasiah, 2021). This perception arises because students have judged that mathematics is always related to numbers, formulas, and calculations. This thinking influences the mastery of mathematical competence because of the fear that arises before students learn it.

The five competencies in mathematics learning established by the National Council of Teachers of Mathematics (NCTM) are mathematical problem-solving, mathematical communication, mathematical reasoning, mathematical connections, and mathematical representations (Hafriani, 2021). Capabilities that include these five competencies can be poured into mathematical literacy. Three main things are the main ideas of the concept of mathematical literacy, namely (1) the ability to formulate, apply, and interpret mathematics in various contexts, which are from now on referred to as the mathematical process, (2) the involvement of mathematical reasoning and the use of mathematical concepts, facts, and tools to describe, explain, and predict phenomena, and (3) the benefits of mathematical literacy

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skills, namely being able to help someone apply mathematics to everyday life as a form of constructive and reflective community involvement.

Based on the results of the Program for International Student Assessment (PISA) showing that Indonesia is ranked 73 out of 79 countries in the field of students' mathematical literacy abilities, the average score obtained is lower, namely 379 points from the standard provisions (Pradinar et al., 2021). These results indicate that students' mathematical literacy skills could be higher. When students face problems that require reasoning and analysis, students tend to think the questions are difficult even though the mathematical concepts are general (Deda et al., 2020). Not only that, the majority of students can only solve problems below level 2. Students' mathematical literacy skills in Indonesia still need to be improved. Several factors influence the achievement of mathematical literacy in Indonesia, including personal, instructional, and environmental factors (Madyaratri et al., 2019). The personal factors studied were students' perceptions of mathematics and students' belief in mathematical abilities, as instructional factors related to intensity, quality, and teaching methods. Environmental factors are related to teacher characteristics, the availability of learning media in schools, and even the applied learning model.

Creating fun and interesting learning, especially for elementary school students, is the main focus of practitioners in the field of education, especially teachers. Researchers have developed many models to create fun learning, one of which is the problem-based learning model. The problem-based learning model focuses on problem-solving activities (Yulianti & Gunawan, 2019). Problem-solving activities, especially those related to everyday life, will make students active, especially in finding answers to the problems given by the teacher (Cahyani & Setyawati, 2016). In practice, the teacher is not oriented towards this model, but the teacher only looks at the thoughts conveyed by students, the opinions and motivation of students to express their opinions, and occasionally the teacher may not ignore student opinions, even if the student's opinion is wrong according to the teacher (Hotimah, 2020; Rahmadani, 2019). PBL is a solution that can help students improve the skills students need in the current era of globalization, including mathematical literacy skills.

Several studies related to the Problem-based Learning learning model include the application of the PBL model in mathematics learning (Tyas, 2017), the HOTS-oriented PBL model in mathematics (Zainal, 2022), the PBL model to improve the mathematics learning outcomes of elementary school students (Astuti et al., 2021; Octaviana et al., 2018), PBL in mathematics learning to increase student interest and achievement (Mashuri et al., 2019), the PBL model of mathematical problem-solving abilities and learning independence (Reski et al., 2019) as well as the application of the PBL model to students' scientific literacy in elementary school students (Indrawan et al., 2022). However, several existing studies have yet to find the application of the PBL model that focuses on students' mathematical literacy abilities. As for what is related to literacy, even scientific literacy is not specific to mathematical literacy. Therefore, this research was conducted to look at the effect of applying the PBL model on the mathematical literacy skills of elementary school students.

METHODS

This research is quasi-experimental (Quasi Experiment), using pretest and post-test designs. The population is all 5th-grade students at SD Muhammadiyah 08 Cilacap for the 2021/2022 academic year. The research sample was taken using the purposive sampling technique, so that class 5A was selected as the control class and class 5B as the experimental class.

The data collection instrument in this study was five description questions. Before the instrument is used, the test instrument has passed theoretical validity and empirical validity. The instrument questions used have been declared to meet the criteria of validity, reliability, level of difficulty, and the distinguishing power of the questions that have been determined. The test instrument was declared valid after being tested for validity with SPSS 25 software, with the results of the R count test for each item being greater than the R table of 0.312. Therefore, each item was declared valid and could be used in research. The test was declared reliable because the pretest had a Cronbach`s alpha value of 0.604, higher than 0.6.

The questions in the research can be used after passing the difficulty level test. Table 1 below shows the test results of the difficulty level of the questions.

Table 1. The Results of the Difficulty Level Test

No	Difficulty Level	Category
1	0.727	Easy
2	0.765	Easy
3	0.792	Easy
4	0.587	Currently
5	0.476	Currently

Based on the item difficulty analysis results, the questions can be used to collect research data because the items are not too easy, and everything is easy. After testing the difficulty level of the questions, the discriminating index test was performed. Based on the discriminating index analysis results, the questions already have a fairly good discriminating power, meaning that the questions can distinguish between students who have mastered the material and those who have not mastered material.

The data collection step was carried out by giving the same pretest questions to students to find out students' initial abilities. Furthermore, the control class was given treatment with learning models without PBL, and the experimental class was given treatment with learning models with PBL, and each class carried out four meetings. After students were given treatment, both classes were given a post-test to see the effect or increase in learning outcomes.

After the pretest and post-test were carried out in both classes, the researchers performed prerequisite tests, namely the normality, and homogeneity tests, using SPSS 25 software. The value obtained was greater than 0.05. Therefore, the data has been distributed following a normal curve. The significance of the homogeneity test of the post-test values of the control and experimental classes was 0.069, which was higher than 0.05. Therefore, the sample of this research was homogeneous, or the data group had the same variance. After the data was known to be normally distributed and homogeneous, a hypothesis test was carried out, namely the t-test, to see the effect or increase in mathematical literacy. The data analysis process was assisted by Microsoft Excel 2010 and SPSS 25.

RESULTS AND DISCUSSION

The PBL learning model provides new experiences to students in mathematics learning, especially in training students' mathematical literacy skills. In this study, learning was carried out in four meetings with 30-40 minutes duration. The teacher is in charge of providing mathematics learning material following the learning design adapted to the material. After the teacher conveyed the lesson, the PBL model with mathematical literacy was. By learning the PBL model using mathematical literacy, students are excited, and their enjoyment of mathematics learning increases in class.

This study used two classes, namely the control and experimental classes, with the number of students in each class totaling 20 students. The control class consisted of 12 female and eight male students, and the experimental class consisted of 6 female and 14 male students. During the learning process, students can understand the learning objectives of the indicators in the material independently, students can define and organize problems, students can solve problems, and students can solve problems and provide conclusions related to problems in mathematics learning. In the learning process in the control class, students have low curiosity about problems. In contrast, in the experimental class, students are more active, have high curiosity, and can solve problems independently. The cultivation of mathematical literacy is carried out by giving directions to students to read, define, analyze, and solve problems. The learning process of the PBL model is seen from the student's ability to solve problems and conclude problems.

The data from this study were obtained from the total post-test answer scores that students had done. To find out whether the post-test data in the control class and the experimental class were normally distributed and homogeneous, a prerequisite test was carried out. The normality test uses the Kolmogorov-Smirnov formula with SPSS 25 software. Table 2 is the result of calculating the normality test on the pretest data.

Table 2. Normality Test Results

		Kolmogorov-Smirnova			Shapiro-Wilk		
	Class	Statistics	df	Sig.	Statistics	df	Sig.
Learning outcomes	Control	.239	20	.004	.909	20	062
	Experiment	.145	20	.200*	.918	20	.090

Source: Primary Data, 2022

Based on the results of the normality test using SPSS 25 software in table 2, it can be seen that the samples have been normally distributed, as evidenced by the results of the normality test in the control class obtaining a significance of 0.062 and in the experimental class of 0.090 where the value is greater than 0.05. It can be concluded that the data has been distributed following a normal curve so that Ho is declared accepted.

After the data is declared to be normally distributed, a homogeneity test is carried out to test whether the sample is from a homogeneous population. The homogeneity test in this study used the sum of the post-test answer scores that students had done. Homogeneity test using the F test formula with SPSS 25 software. The results of the homogeneity test can be seen in table 3.

Table 3. Homogeneity Test Results

		Levene Statistics	df1	df2	Sig.
Learning outcomes	Based on Means	3,514	1	38	.069
	Based on Median	2,715	1	38	.108
	Based on the Median and with adjusted df	2,715	1	25,907	.111
	Based on trimmed mean	3,253	1	38	079

Source: Primary Data, 2022

Based on the homogeneity test results contained in table 3, it can be seen that the significance value was 0.069, which was higher than 0.05. Therefore, the sample in the study was homogeneous, or the research data group had the same variance. After the prerequisite test was carried out on the students' post-test results, hypothesis testing was carried out. Calculations were performed using the t-test calculations on independent sample t-test and paired sample t-test.

The PBL learning model has several syntaxes used in the class learning process. According to Setyowati & Mawardi (2018), syntaxes in the PBL model learning are (1) orienting students to a problem; (2) organizing students to research; (3) investigating students independently; (4) collecting the results of the work on the questions promptly; (5) analyze and evaluate the process of solving problems. Syntax in research is used as a guide in the learning process in class.

Table 4. The Syntax of Problem-based Learning (PBL) Model with Mathematical Literacy

No.	Learning steps	Learning Activities	Student Condition
1.	Familiarize students with a problem.	1. Students read the learning objectives of the indicators in the questions. 2. Students read the steps for working on the problem. 3. The teacher gives motivation to students before problem-solving activities on the questions.	Students can understand the learning objectives and the steps to do well and avoid problems in working on the questions after the teacher provides motivation and direction before starting to work on the questions.
2.	Organizing students to research.	1. The teacher assists students in defining and organizing tasks on questions.	Students can understand the task of the questions that the teacher has explained.
3.	Investigate students independently.	1. The teacher encourages students to answer questions by using problem-solving stages.	Students can work on questions with the stages of the problem-solving process of the questions.
4.	Collect the results of the work on the questions in a timely manner.	1. Students can solve questions correctly.	Students can solve problems at the right time.
5.	Analyze and evaluate processes in solving problems.	1. The teacher gives an evaluation related to the questions given.	Students can understand and absorb the material from the questions as a problem-solving learning process.

The free sample t-test (independent sample t-test) in this study was conducted to analyze whether there were significant differences between the control and experimental

classes using the PBL learning model. The data used in the free sample t-test are the post-test values in the control and experimental classes. The results of the free sample t-test are in table 5.

Table 5. Free Sample t-test

		Levene's Test for Equality of Variances		T-test for Equality of Means						
		F	Sig.	Q	df	Sig. (2 tailed)	Mean Differences	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Learning outcomes	Equal variances assumed	3,514	.069	-4,939	38	.000	-14,100	2,855	-19,88	-8,320
	Equal variances not assumed.			-4,939	29,402	.000	-14,100	2,855	-19,93	-8,264

Source: Primary Data, 2022

Based on the analysis of the free sample t-test using SPSS 25 software, the calculated t-value is greater than the t-table, namely 4.939 > 2.02439. The significance of the free sample t-test is 0.000, less than 0.05. Therefore, there is a significant difference in student learning outcomes in the experimental and control classes. Thus, the hypothesis is accepted.

Compared to the largest mean, the average value of the experimental and control classes can determine which learning model is the most effective.

Table 6. Statistical Test Results

	Class	N	Means	std. Deviation	std. Error Means
Learning outcomes	Control	20	77.70	11.207	2,506
	Experimental	20	91.80	6.118	1,368

Source: Primary Data, 2022

Table 6 indicates that the average value of the experimental class is higher than that of the control class (91.80 > 77.70). Therefore, the problem-based learning model with mathematical literacy is more effective than conventional models at SD Muhammadiyah 08 Cilacap.

The second hypothesis test was carried out using paired sample t-test to analyze whether the PBL learning model with mathematical literacy significantly affects student learning outcomes. Paired sample t-tests were carried out using pretest and post-test values in the experimental class. The results of the paired sample t-test can be seen in table 7.

Table 7. Paired Sample t-test

		Means	Std. Deviation	std. Error Means	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Before - After Treatment	-29,650	17,064	3,816	-37,636	-21,664	-7,771	19	.000

Source: Primary Data, 2022

Table 7 shows that the obtained t_{count} value is greater than the t_{table} (7.771 > 2.09302), with a significance of 0.000, less than 0.05. Therefore, the problem-based learning model with mathematical literacy significantly influences student learning outcomes. Based on the results of the analysis of hypothesis testing data, the experimental class had higher mathematical literacy abilities than the control class.

The learning model is a plan or pattern used to guide classroom learning (Wildaniati, 2019; Khoerunnisa & Aqwal, 2020). An innovative learning model will give students new experiences that maximize learning in class. According to Husnidar & Hayati, (2021), the PBL learning model can improve problem-solving skills, memory, understanding, and knowledge relevant to the world of practice, encourage full thinking, and build leadership abilities, collaboration, study skills, and motivation. The PBL learning model provides many benefits to the learning process that students will obtain by familiarizing themselves with problems. So that in the future, students can independently determine their direction and actions.

Based on the results of the data analysis, the experimental class got higher scores than the control class in mathematical literacy skills. This is influenced by the use of the learning model with the PBL model which will focus on students (student-centered) who will be trained to solve problems in real life by emphasizing students on communication, collaboration, formulating ideas, and developing their reasoning skills. According to Sulistio et al., (2020), the PBL learning model plays a role during the learning process, and real problem-solving can influence the high motivation and curiosity of students so that it can familiarize and improve students' mathematical literacy skills. The PBL learning model with mathematical literacy involves students participating in the learning process (student-centered). Therefore, they can express their problem-solving process in solving, formulating, and interpreting their problems.

The results of data analysis showed that the experimental class students increased their mathematical literacy skills better than the control class because the model's syntax can train students to improve their mathematical literacy skills, compared to the control class, which uses conventional learning models. According to Setiyawan, (2017), mathematics learning with the PBL model exposes students to problems aimed at training and facilitating students to solve the problems they face using their mathematical knowledge to improve their mathematical literacy skills. Learning the PBL model through a reasoning process makes students look for problems through observation and experimentation in gathering information to find problem-solving strategies that can train students' mathematical literacy.

Habituation of learning with the PBL model needs to be done so that students can get used to understanding problems with mathematical literacy, which is difficult for students because they are not used to simple questions. Hence, students need to be more optimal in solving problems with mathematical literacy. Firdaus et al. (2021) explained that the PBL learning model could increase students' mathematical literacy because the stages or syntax in the PBL model contain problem identification, independent learning, investigation, exchange of knowledge, and assessment. Therefore, it will create a generation that is ready for the challenges in the future.

CONCLUSIONS

Based on the results of processing and analysis of research data conducted at SD Muhammadiyah 08 Cilacap for the fifth-grade students in the 2021/2022 academic year, the effect of the PBL model with mathematical literacy was more significant than conventional learning models. The PBL model with mathematical literacy increased students' learning outcomes more than conventional learning models with mathematical literacy.

AUTHOR CONTRIBUTIONS STATEMENT

WH is in charge of providing research ideas, making initial observations, and preparing all the instruments needed for research. MJ is in charge of collecting data, analyzing data, and compiling discussions. In addition, MJ was in charge of writing articles, while WH reviewed the entire article and played a role in providing suggestions.

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