World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Applying scaffolding technique in Problem Based Learning (PBL) model on students' mathematics problem solving ability

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World Journal of Advanced Research and Reviews, 2024, 21(03), 1372–1379

Publication history: Received on 04 February 2024; revised on 12 March 2024; accepted on 14 March 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.3.0846

Abstract

This research aims to: (1) describe the factors that influence low mathematical problem solving abilities and the average increase in each indicator of mathematical problem solving abilities; (2) determine the effect of applying scaffolding techniques in the PBL model on mathematical problem solving abilities. The subjects of this research were class VIII students at SMPN 5 Kendari. Qualitative and quantitative methods were used in this research. The results of this research are: (1) Factors that influence students' low mathematical problem-solving abilities are the rare practice of questions related to problem solving and the learning model used by teachers is not suitable for learning mathematical problem solving. The average increase in each indicator of mathematical problem solving ability using the PBL model and DI model is: (a) understanding the problem 57.2 to 76.9 and 56.8 to 59.3; (b) solve questions 52.4 to 75.8 and 51.6 to 57.3; (c) answer questions 40.4 to 65.8 and 41.2 to 47.5; (2) students taught using the PBL model have higher scores than students taught using the DI model, so there is an influence of implementing the PBL model in improving the mathematical problem solving abilities of students at SMP 5 Kendari.

Keywords: Problem-based learning; Scaffolding technique; Mathematics problem solving

1. Introduction

The focus of mathematics learning in schools from elementary school to high school is a problem-solving approach. This is in line with the opinion of Jonassen [1] which states that the main focus in learning mathematics is the problem-solving approach. The problem-solving approach is implemented to provide adequate provisions to students, to gain knowledge in forming ways of thinking and behaving in solving various problems faced [2]. [3] analyzed developments that will occur in the 21st century and identified 5 new conditions or contexts in life, each of which requires certain competencies. One analysis of the results is to anticipate global challenges that require mathematical problem-solving abilities. Mathematical problem solving is an important thing to be given to students in learning mathematics as a continuation of mental activity consisting of various skills and cognitive actions intended to obtain the right solution [4], [5].

Problem solving is still difficult for students to understand and this is also a phenomenon that occurs at SMPN 5 Kendari as shown by the average results of the initial test of mathematical problem-solving abilities carried out by researchers during preliminary learning which obtained an average score of 36.48. This is because students are not trained in mathematical problem-solving abilities and the learning model used by teachers is not suitable for improving students' mathematical problem-solving abilities.

Various research has been carried out to improve mathematical problem-solving abilities, including:[6]with cooperative learning; [7] with the discovery learning model; [8] with a realistic mathematical approach; [9] with a scientific approach; [10] using a problem-based learning model; [11] by collaborating the problem-based learning

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model with the Jigsaw type cooperative learning model. However, the PBL learning model with scaffolding has not been applied to improve mathematical problem-solving abilities.

To improve mathematical problem-solving abilities, an appropriate learning model is needed. One learning model that can be used to improve students' mathematical problem-solving abilities is the problem-based learning (PBL) model[12], [13]. The PBL model directs students to connect new information with previously held knowledge, then build knowledge and develop it into new schemes through collaborative learning [14], [15], [16]. PBL is a learning approach that allows students to conduct research, integrate theory and practice, and apply knowledge and skills to develop solutions to certain problems [14]. PBL is learning that presents various authentic and meaningful problem situations to students and works together to find solutions to complex problems [17].

To solve mathematical problems, students can be helped to understand mathematical concepts that will be used in solving mathematical problems, one of which is by providing scaffolding[18]. Scaffolding aims to reduce the gap between the actual level of development and the level of potential development in solving mathematical problems [19]. Scaffolding in this research is providing a certain amount of assistance to students in the early stages of learning and then reducing this assistance and giving students the opportunity to assume greater responsibility as soon as they are able to solve their own problems [19]. Providing scaffolding in learning to solve mathematical problems based on the cultural environment and social interaction has an important role in the development of human traits and types who can learn through interaction with adults and more capable peers so that they can stimulate new ideas and enrich students' intellectual development [20], [21].

Based on the description above, it can be said that the PBL model and scaffolding techniques can improve mathematical problem-solving abilities. This is supported by several research results, including: [20], [22], shows that increasing students' problem-solving abilities based on direct learning, and the PBL model have a positive impact on the development of students' mathematical problem-solving abilities. This research aims to improve mathematical problem-solving abilities

2. Material and methods

There are two types of methods used in this research, namely qualitative methods and quantitative methods. Qualitative methods were used to explore in depth the factors that influence the low mathematical problem-solving abilities of students at SMP 5 Kendari. To find out in depth about the factors that influence students' low mathematical problem-solving abilities by using interview techniques. Interviews were conducted with six students, namely one student who had high abilities in the experimental class and another student in the control class; one student with moderate abilities in the experimental class and another student in the control class; one student with low ability is in the experimental class and one student with low ability is in the control class.

Quantitative methods were used to describe the mathematical problem-solving abilities of students from two research groups, namely the first group as the experimental class and the second group as the control class. This research is quasi-experimental research. The design in this research is a pre-test-post-test control group design. The population in this study were all class VIII students at SMPN 5 Kendari consisting of eleven parallel classes and samples were taken from two parallel classes, namely class VIII-B, totaling 36 students and class VIII-D, totaling 35 students randomly.

To determine the experimental class and control class in this study, a simple random sampling technique was used. Based on the random results, Class VIII-B was designated as the experimental class and Class VIII-D as the control class. Determining the experimental class and control class using simple random sampling techniques. The focus of this research is to look at the average increase in each indicator of students' mathematical problem-solving abilities after being taught using scaffolding techniques embedded in the PBL model and taught to students using the DI model. Therefore, before applying the scaffolding technique embedded in the PBL and DI models, the two samples were given a pre-test regarding mathematical problem-solving ability questions. The average pre-test math problem solving ability for Class VIII-B was 41.7 and Class VIII-D was 49.7. After that, Class VIII-B as an experimental class was taught using scaffolding techniques embedded in the PBL model and Class VIII-D as a control class was taught using the DI model. After being taught eight times per class with the Pythagorean Theorem material, both classes were given a post test on mathematical problem-solving questions related to the Pythagorean Theorem. To see the average increase in each indicator or Normalized Gain (N-Gain) of mathematical problem-solving abilities from pre-test results to post-test results descriptively using the N-Gain criteria in Table 1.

Table 1 Normalized Gain (N-Gain) Criteria

N-Gain	**Criteria**
$N - Gain$ > 0,7	High
0,30 ≤$N - Gain$≤ 0,7	Moderate
N - Gain< 0,3	Low

The hypothesis in this study was: the average improvement of each indicator of mathematics problem solving ability of students taught with scaffolding technique embedded in PBL model is higher than the students taught with the DI model. Statistically this hypothesis is formulated as follows:

$H_0: \mu_1 = \mu_2$ while $H_1: \mu_1 > \mu_2$

Information:

$H_0 : \mu_1 = \mu_2$ (there is no difference in the average improvement in each indicator of mathematics problem solving ability between students taught with scaffolding technique embedded in PBL model and students taught with DI model).

$H_1 : \mu_1 > \mu_2$ (average improvement for each indicator of mathematics problem solving ability of students taught with scaffolding technique embedded in PBL model higher than students taught with DI model).

The decision-making criteria for α = 0.05 are as follow: If $\frac{sig\ (2-tailed)}{2}) \geq \alpha = 0{,}05$ then H_0 is accepted dan If $\frac{sig\ (2-tailed)}{2} < \alpha = 0{,}05$ then H_0 is rejected.

3. Results

The preliminary data of this study were qualitative data from interviews with six students. Data from in-depth interviews with six students about the factors that influence the low ability of students' mathematics problem solving ability conducted by the Researcher (P) on each Research Subject (SP) are presented below. Sample result of interviews with research subjects (SP-1) students who are highly skilled in the experimental class is listed below:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?
- SP-1 : The problem of mathematical problem solving is rarely taught, Sir.
- P : Are there other things that cause low mathematical problem-solving abilities?
- SP-1 : (Thinking). The way teachers teach mathematics related to problem solving is not appropriate.
- P : Is there anything else?
- SP-1 : No more sir.

Footage of the results of the interviewer's Research with the Subjects of the two (SP-2) students who are highly capable in the control class are:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?
- SP-2 : Problem solving is rarely taught, Sir.
- P : Are there other things that cause low mathematical problem-solving abilities?
- SP-2 : The way teachers teach mathematics related to problem solving is not appropriate.
- P : Is there anything else?
- SP-2 : That's it, sir.

Footage of the results of the interviewer's Research with the third Research Subjects (SP-3) students who were of moderate ability in the experimental class were:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?

- SP-3 : Mathematical problem solving is rarely taught, Sir.
- P : Are there other things that cause low mathematical problem-solving abilities?
- SP-3 : The way teachers teach mathematics related to problem solving is not appropriate.
- P : Is there anything else?
- SP-3 : That's it, sir.

Footage of the results of interviews of Researchers with Research Subjects four (SP-4) students who are of moderate ability in the control class are:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?
- SP-4 : Problem solving problems are rarely taught, Sir.
- P : Are there other things that cause low mathematical problem-solving abilities?
- SP-4 : The way teachers teach mathematics related to problem solving is not appropriate.
- P : Is there anything else?
- SP-4 : No more sir.

Footage of the results of interviews of Researchers with Research Subjects five (SP-5) students who were of low ability in the experimental class were:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?
- SP-5 : Mathematical problem-solving questions are rarely given, Sir.
- P : Are there other things that cause low mathematical problem-solving abilities?
- SP-5 : No more sir.

Footage of the results of the interviewer's Research with Research Subjects six (SP-6) students who are low in the control class are:

- P : What makes it difficult for you to solve mathematical problem-solving questions, which results in your low ability to solve mathematical problems?
- SP-6 : Examples of problems solving questions are rarely given.
- Q : Is there anything else that causes that?
- SP-6 : No more sir.

After the interview process was carried out before being given treatment, it was seen that the answers of the research subjects were relatively the same, namely the lack of students being trained in questions related to mathematical problem-solving abilities. In addition, information is obtained that the way the teacher teaches problem solving is not right. This means that the ability to solve mathematical problems must often be trained in mathematics learning, then must apply the appropriate learning model in teaching mathematical problem solving.

Table 2 Distribution of Average Indicators' Improvement of Mathematics Problem Solving Ability Based on Pre-test and Post-test on Experiment Class and Control Class

Indicators	**Experiment Class**			**Control Class**		
	Average		*N-Gain*	Average		*N-Gain*
	Pre-test	*Post test*		*Pre-test*	*Post test*	
Understanding Problems	57.2	76.9	0.46	56.8	59.3	0.06
Solving Problems	52.4	75.8	0.49	51.6	57.3	0.12
Answering Questions	40.4	65.8	0.42	41.2	47.5	0.11

The quantitative data of this study were analyzed descriptively and inferentially. Descriptive analysis was carried out to see the average distribution of improvement for each indicator of students' mathematics problem solving ability based on pre-test and post test scores in the experimental class and control class and the results are presented in table 2.

Based on Table 2, it shows that the average improvement in each indicator of mathematics problem solving ability of experimental class who were taught with scaffolding technique embedded in PBL model has increased with moderate criteria, which is 0.30 ≤ N-Gain ≤ 0.7, while the average improvement of each indicator of mathematics problem solving ability of control class who were taught by DI model also increased with low criteria, namely N-Gain < 0.30. Based on the results of descriptive analysis, it shows that the improvement quality of each indicator of students' mathematics problem solving ability in the experimental class is higher than the quality of the improvement of each mathematics problem solving indicator of students in the control class. This shows that scaffolding technique embedded in PBL model is better than DI model to improve students' problem-solving ability.

Furthermore, inferential analysis is carried out, namely to test the hypothesis of the study. To do inferential analysis, the SPSS program is used, and the results are presented in Table 3.

Table 3 Results of Statistical Analysis of Mean Difference Test for Students' Mathematics Problem Solving Ability of Experiment and Control Classes

	Levene's Test for Equality of Variances		**t-test for Equality of Means**				
	F	**Sig.**	**t**	**df**	**Sid(2-tailed)**	**Mean Difference**	**Std. Error Difference**
Equal variances assumed	0,510	0.479	4.799	48	0.000	0.23720	0.4942
Equal variances not assumed			4.799	46.296	0.000	0.23720	0.4942

Source: Primary data is processed with the SPSS program.

Based on Table 3, it is obtained that $\frac{sig\ (2-tailed)}{2} = \frac{0,000}{2} = 0,000 < \alpha = 0,05$ then H_0 is rejected or accept H_1. By rejecting H_0, it can be concluded that the average improvement in each indicator of students' mathematics problem solving ability in the experimental class who were taught with scaffolding technique embedded in PBL model is higher than the average improvement of each indicator of mathematics problem solving ability of students in the control class who were taught with DI model.

4. Discussion

Based on the results of the qualitative analysis, it was found that mathematical problem-solving questions were rarely taught to students and the teacher's way of solving problems was not appropriate. This means that questions related to mathematical problem-solving abilities must be drilled frequently and the learning model used must be appropriate, namely the PBL model. Solving mathematical problems is still considered difficult by most students. Therefore, students' mathematical problem-solving abilities are still low. To improve mathematical problem-solving abilities, students need an appropriate learning model. One learning model that can be used to improve students' mathematical problem-solving abilities is the PBL model.

The results of this research show that both descriptively and inferentially, the increase in the mathematical problem-solving abilities of students taught using the scaffolding technique embedded in the PBL model is higher than the mathematical problem-solving abilities of students taught using the DI model before and after treatment. This is because through the PBL model, teachers offer various authentic problems so that students are required to be active in solving the problems given. In addition to applying the PBL model, students are directed to connect new information with previously held knowledge, then build knowledge and develop it into new schemes through collaborative learning [23], [24], [25]. Related to this, [17] revealed that through the PBL model, solving mathematical problems is done by thinking in small groups together and looking for information between one student and another, so that the problem can be resolved. In a similar vein, [26], stated that PBL is a learning approach where students work together to find solutions to complex problems. Apart from that, students who experience difficulties in solving mathematical problems are given assistance by teachers and other students who have better abilities.

The results of this research are supported by several other research results which show that the scaffolding technique embedded in the PBL model is better than the direct learning model, this is related to mathematical problem-solving abilities. The research results of [27], [28] show that the use of the PBL model is more effective than the DI model in

learning mathematics when viewed from the aspect of problem-solving ability. [10] research results show that students' abilities in learning and using the PBL model are better than students taught using the DI model. Study Results [29] showed that PBL is as efficient as the DI model in improving students' mathematics performance.

Scaffolding can increase students' creativity and thinking abilities. So, in other words, learning that uses scaffolding techniques really helps students build creativity in solving mathematical problems. This is in accordance with the results of research by [30] which shows that scaffolding can foster students' creativity and divergent thinking skills, as well as increase their independence, understanding and self-confidence in mathematics. The scaffolding technique embedded in the PBL model can improve students' mathematical problem-solving abilities. Therefore, the scaffolding technique embedded in the PBL model can be used as an alternative learning model for teaching mathematics, especially for teaching mathematical problem solving.

5. Conclusion

Based on the results of the research and discussion, it can be concluded: (1) the factors that influence the low ability to solve mathematical problems are that students rarely work on questions related to problem solving and the learning model used by teachers is not appropriate. to teach mathematical problem solving. The average increase in each indicator of mathematical problem-solving ability using the PBL model and DI model is: (a) understanding the problem 57.2 to 76.9 and 56.8 to 59.3; (b) solve questions 52.4 to 75.8 and 51.6 to 57.3; (c) answer questions 40.4 to 65.8 and 41.2 to 47.5; (2) students taught using the PBL model have higher scores than students taught using the DI model, so there is an influence of applying the PBL model in improving students' mathematical problem solving abilities.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have declared no conflict of interest in relation to this article.

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