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The problem-based learning model with statistics board in improving students' problem-solving abilities

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ABSTRACT

This research aims to determine the differences in problem-solving abilities between students who receive teaching through a problem-based learning approach supported by teaching aids and students who receive direct teaching in statistics subjects in class VIII. This research method is quantitative, and it applies a repeated experimental research type with a research design (pre-test-post-test control group design). This research was conducted at MTs Ma'arif Roudhotut Tholibin with samples of classes VIII A and VIII B. Data collection instruments were assessment validation sheets, pre-test and post-test sheets and documentation. The data analysis technique used is the Independent samples t-test. This research shows that the average score for students who used the problem-based learning model with statistics board teaching aids was 81.30, and the student's group who used the direct learning model was 59.80. Thus, descriptively, it can be concluded that there is a significant difference between the problem-solving abilities of the students group who use the problem-based learning model with statistics board teaching aids and the students group who use the direct learning model.

1. Introduction

Education is a critical element in determining the quality of human resources. The government is actively trying to improve the quality of education by improving the curriculum (Tenriawaru et al., 2020). Education, following Law No. 20 of 2003 concerning the National Education System in Article 1, is a deliberate and planned effort to create a learning space and learning system in which participating students explore their qualities in order to obtain spiritual aspects, self-control, identity, intelligence, morality and capabilities required himself and the surrounding environment. Learning is a significant method of shaping the human ability to use rationality effectively and efficiently in facing various challenges that arise to create a bright future (Hasanah et al., 2021).

Mathematics plays a crucial role in the science framework. So mathematics subjects are always included in all education stages. (A. D. Lestari et al., 2020). Until now, mathematics subjects remain challenging for students because they are considered difficult to understand. One factor is that mathematics involves abstract concepts that cannot be visualized directly, so students need a deep understanding of the concepts to understand this material (Nurzazili et al., 2018).

Based on research conducted at MTs Ma'arif Roudhotut Tholibin, Metro, it was found that student participation in the learning process in class, especially during mathematics lessons, was still relatively inactive (Jannatul Ngaliyah, interview, 10 October 2023). One challenge that hinders active

participation in the teaching and learning process at MTs Ma'arif Roudhotut Tholibin, Metro, especially in mathematics lessons, is students' difficulty understanding lesson content and completing assignments. When learning occurs, after the teacher explains the material, efforts are made to involve students by asking them questions about the material that has just been taught. However, there are problems with the current learning methods, where students listen more, take notes, follow the teacher's instructions, and are less actively involved in the learning process. Therefore, students have not reached the expected activity level regarding asking questions and having the skills to formulate and solve questions independently. Students still often follow the same approach as the teacher. There are situations where students feel bored while studying, resulting in problems in understanding the lessons the teacher delivers. Thus, students' problem-solving abilities are still limited. In this context, the learning approach used does not appear to be appropriate, which impacts students' inability to face challenges in learning and lack of skills in solving or resolving questions given by the teacher.

One action that can be taken to improve the ability to solve problems is to improve the learning process. Experts and researchers recommend adopting learning models to improve the learning process. One learning model that has the potential to improve the ability to solve problems is a problem-based approach (Ariandi, 2017). Using the PBL approach can enrich students' abilities in stimulating thinking processes, communicating, and connecting their ideas in solving problems, ultimately increasing their intellectual capacity.

The Problem-Based Learning approach is a teaching method that emphasizes the transition of students from receiving the knowledge conveyed to being responsive participants, enabling the development of problem-solving skills. Applying the PBL model occurs when the teacher designs and implements learning by presenting problems to students. The teaching process using the PBL approach requires more time to formulate the solutions proposed by the teacher. Therefore, it needs to be adjusted to the learning design plan. An alternative solution for problem-based learning involves students in independent learning by utilizing relevant teaching materials (Ramadanti et al., 2021).

In the PBL approach, the teacher's role is no longer in front of the class as the sole authority providing lessons. In the PBL class, the teacher acts as a facilitator. The teacher's job is to direct the group, not just transfer knowledge. One facilitation technique teachers can use is the demonstration method, which involves displaying props, models or replicas. The main objectives of the demonstration method are: 1) explaining and concretizing the lesson material; 2) facilitate students' understanding; 3) increase students' interest in the material; 4) stimulate students to observe actively; and 5) focus students' attention (Santoso et al., 2020).

Teaching aids are instruments teachers and students use during the classroom teaching process to present various teaching methods to achieve the desired results. Teaching aids in teaching mathematics can enrich the learning experience and create an exciting learning atmosphere, increasing students' motivation in each mathematics lesson and potentially increasing their learning achievement (Purbaningsih, 2017).

2. Method

This research method uses a quantitative approach. The researcher implemented a type of repeated experimental research with a research design (pre-test-post-test control group design), a type of experiment that involves randomization in two groups, namely the control group and the experimental group (Abraham & Supriyati, 2022). The sample for this research was MTs Ma'arif Roudhotut Thlolibin class VIII students. Class VIII A is the experimental class, and Class VIII B is the control class. This experimental design involves measurements or observations before and after treating the two groups. The experimental group will use a problem-based learning approach in this research, while the control group will apply a direct learning approach.

Two types of instruments will be used: learning planning instruments and instruments used to collect research data. Learning planning instruments include lesson plans, syllabi, processes, porta, and learning media as statistics board teaching aids. Instruments for collecting research data include validation sheets, pre-test and post-test questions, and documentation. The data analysis technique used is a test of two independent samples (*independent samples t-test*).

The research instrument that has been designed and tested to obtain an empirical understanding of the suitability of the test is used as a research tool. Then, three experts tested the instrument's content validity to evaluate the relevance of the test that had been created. Next, an experiment was carried out, and the results were used to test the validity and reliability of the research instrument using the Aiken index. Meanwhile, for the reliability test, the *Alpha Cronbach formula*. Before carrying out a hypothesis test, a prerequisite test is first carried out, namely the normality and homogeneity test. Then, to calculate the two independent sample tests, use the following formula:

3. Findings

Table 1. Level of Difficulty and Differentiating Power

	Question Item Number				
	1	2	3	4	5
Total score	51	47	33	48	50
Number of test takers	20	20	20	20	20
Mean item score	2.55	2.35	2.05	2,4	2.5
Maximum score	4	4	4	4	4
P (TK Index)	0.63	0.58	0.51	0.6	0.62
DB Index	0.387	0.548	0.523	0.351	0.393

Table 2. Validity Test

No.	Expert 1	Expert 2	Expert 3	S1	S2	S3	Σ s	n(c-1)	V	Category
1	5	5	4	4	4	3	11	12	0.91	High
2	5	5	4	4	4	3	11	12	0.91	High
3	5	4	3	4	3	3	10	12	0.83	High
4	5	5	4	4	4	3	11	12	0.91	High
5	5	5	4	4	4	3	11	12	0.91	High
1-5	25	24	25	20	19	14	54	60	0.88	High

After conducting validity testing, the next step is to conduct reliability testing using the Cronbach alpha formula to assess the level of reliability of the research instrument to be used and determine whether the instrument is suitable for application in this research. The instrument is said to have good reliability if the Cronbach Alpha value is > 0.70.

Table 3. Reliability Test

Reliability Statistics

Test	Cronbach's Alpha	N of Items
Pre-Test	,760	5
Post-Test	,729	5

In the table, the pre-test and post-test in this study show reliability of 0.760 and 0.729, respectively. This indicates that the instruments used by researchers in data collection are reliable.

Test Prerequisites

Table 4. Normality Test

Tests of Normality

	MODEL	Kolmogorov-Smirnov [a]			Shapiro-Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
MARK	1	,088	20	,200 *	,961	20	,572
	2	,140	20	,200 *	,922	20	,107

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

From the table above, it can be concluded that the value for model 1 Shapiro-Wilk sig = 0.572, which means it is more than the alpha value, namely 0.05, so it can be determined that model 1 H0 is accepted. Then, for model 2 Shapiro-Wilk sig = 0.107, which means it is more than the alpha value, namely 0.05, it can be determined that model 2 H_0 is accepted. So, the conclusion is that the problem-based learning group with statistical board teaching aids and the direct learning group had a normal distribution.

Table 5. Homogeneity Test

Test of Homogeneity of Variance

		Levene Statistics	df1	df2	Sig.
NAME	Based on Mean	1,402	1	38	,244
	Based on Median	1,392	1	38	,245
	Based on the Median and with adjusted df	1,392	1	34,925	,246
	Based on trimmed mean	1,432	1	38	,239

Table 5 shows that the homogeneity test results after treatment obtained a significance of 0.244, where > 0.05, which means that both experimental and control groups received the same or homogeneous variant results.

Two Independent Samples t Test

The independent two-sample t-test is a statistical method used to compare the means of two independent groups with each other. This test tests whether there is a significant difference between the means of the two groups. This t-test considers variations within each group and sample size to determine whether the difference between group means is statistically significant or may occur by chance. The statistical hypothesis can be written as follows.

H_0 : There is no difference in problem-solving abilities between the student group that uses the problem-based learning model with statistics board teaching aids and the student group that uses the direct learning model.

H_1 : There is a difference in problem-solving abilities between students who use the problem-based learning model with statistics board teaching aids and those who use the direct learning model.

Table 6. Descriptive Statistics

Group Statistics

	CLASS	N	Mean	Std. Deviation	Std. Error Mean
MARK	1	20	81.30	5,877	1,314
	2	20	59.80	7,978	1,784

Table 6 shows that the averages are 81.30 and 59.80. Thus, descriptively, it can be concluded that there are differences between students who use the problem-based learning model with statistics board teaching aids and those who use the direct learning model.

Next, to prove whether there is a significant difference, it is necessary to interpret the output of the "Independent Samples T-Test."

Table 6. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	Q	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
MARK	Equal variances assumed	1,402	,244	9,704	38	,000	21,500	2,216
	Equal variances are not assumed.			9,704	34,930	,000	21,500	2,216

Independent Samples T-Test " output table in the "Equal variances assumed" section, it is known that the sig. (2 tailed) 0.000 < 0.05, then based on decision-making, it can be concluded that H0 is rejected. From the table above, it can be seen that the t count is 9.704. Thus, because the calculated t value is 9.704 > t table value = 2.712, as is the basis for decision-making above, it can be concluded that H_0 is rejected and H_1 is accepted, with a significance value (2-tailed) of 0.000 < 0.05, which means that there is a significant difference in solving ability. Problems exist between students who use the problem-based learning model with statistics board teaching aids and those who use the direct learning model.

4. Discussion

Problem-Based Learning

Problem-based learning is a teaching approach that uses challenges to improve problem-solving, understanding learning topics, and students' self-control abilities (D. D. Lestari et al., 2017). Problem-based learning begins by introducing students to real situations or problems relevant to the subject matter. These problems are designed to capture student interest and curiosity. These problems can vary from clinical cases in medical education to social, technical, or scientific problems in other contexts (Siregar, 2020). Students are given the responsibility to explore, analyze and solve the problem. They must formulate questions, find sources of information, and design solutions. This encourages student-centred learning, activates curiosity, and improves research skills (Wardani, 2018).

Students are given the responsibility to explore, analyze and solve the problem. They must formulate questions, find sources of information, and design solutions. This encourages student-centred learning, activates curiosity, and improves research skills (Wardani, 2018). The following steps in PBL: 1) Introduce a relevant problem context and draw students' attention to it. 2) Help students formulate questions or learning objectives related to the problem. 3) Provide the necessary guidance to overcome obstacles and understand the problem. 4) Help students formulate solutions or answers to problems and encourage them to present their work results effectively to the group or class. 5) Involving students in critical reflection on the learning process and assessing the problem-solving process, group collaboration, and student understanding (Syamsidah & Suryani, 2018).

Problem-Solving Abilities

One of the goals of learning mathematics is for students to develop problem-solving abilities (Kurniawati et al., 2019). Students with limited comprehension abilities will tend to have less practical problem-solving skills. Meanwhile, students with comprehension abilities who are in the middle are often difficult to categorize with certainty. This is due to possible variations in levels of understanding, which can range between high and low. (Isnaini, 2018)Problem-solving skills are an aspect that is of great significance in learning mathematics. It is also a key element in students' ability to successfully manage teams and process data or information from non-routine situations. Therefore, students should possess this ability (Ariawan & Pujawan, 2019). When students only focus on finding answers as the only goal to be achieved, they often have difficulty choosing the proper solution technique (Syaf et

al., 2018). (Syaf et al., 2018). Indicators used to measure problem-solving abilities include: 1) understanding the problem, 2) planning a resolution strategy, 3) carrying out the solution according to the plan that has been prepared, 4) verifying or re-checking the answers (Purnamasari & Setiawan, 2019). The ability to solve mathematical problems has high value and can be applied in various aspects of life, not limited to the mathematics domain alone, but also in science, technology and various other professional fields (Sagita et al., 2023).

Statistics Board

Teaching aids in mathematics are objects or devices used to visualize, explain, or illustrate mathematical concepts to students or to understand mathematical concepts to other people (Maulida et al., 2022). These teaching aids help in learning and teaching mathematics by making the material easier to understand and more enjoyable. However, mathematics teachers still refuse to use teaching aids to facilitate students' understanding of the material (Fahma & Purwaningrum, 2021). This affects the learning process and outcomes and often gives rise to conceptual errors among students. The lack of teaching aids in the learning process often results in a less interactive classroom atmosphere, making students feel bored, primarily if the teacher only teaches primary material with a monotonous approach.

In this research, the researcher used a statistical board to help clarify the material and make it easier for students to understand the learning material. The Statistics Board teaching aid facilitates teacher explanations on how to find median, mode, and mean in single data, which is considered relatively simple material. Thus, the Statistics Board effectively aids in teaching mathematics in the classroom.

This statistics board is square and accompanied by small pieces of bamboo and foam. The board is made of styrofoam, which is in various colours. Pieces of styrofoam that people usually sell in shops are several pieces of bamboo covered with coloured cloth. The styrofoam board is here as a place to stick the name of the media, instructions for use and a box with a hole in it for a bamboo stick to stand as a stick for statistics that determines the amount of data.

Figure 1. Statics Board

The following is an overview of how the statistics board props work. Example: From the data, the highest exam scores for seven students were obtained as follows: 2 3 7 7 4 5 7

a. Insert the bamboo stick into the hole in the styrofoam material seven times according to the number of data.
b. After that, pieces of styrofoam were inserted into each bamboo stick according to the amount of data.
c. Arrange the data from smallest to largest: 2, 3, 4, 5, 7, 7, 7.
d. Identify the sorted data's middle value; in this case, the median value is 5.
e. Next, find the value that appears most frequently in the single data above, and in this case, the mode is 7.
f. Next, calculate the average or mean by arranging the pieces of styrofoam on a statistical stick.

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g. Finally, once all the pieces are aligned, calculate the average value by adding the number of styrofoam pieces on each stick. Thus, the mean value of the single data above is 5

Before starting learning, either direct learning or using a problem-based learning model with statistics board teaching aids, do an initial test or pre-test.

Figure 2. Distribution of *pre-test questions*

In the control class, learning is done as usual without using teaching aids and PBL models.

Figure 3. Learning without PBL models and teaching aids

In the experimental class, learning is done by applying the *problem-based learning model* and statistics board teaching aids.

Figure 4. Learning using statistics board and PBL models

After learning, students are given post-test questions in each class to determine their problem-solving abilities.

Figure 5. Distribution of *post-test questions*

Statistics board displays provide a clear visual representation of statistical concepts. By using a board and visual aids such as graphs, diagrams, or tables, students can see directly the relationship between relevant variables. This helps students understand statistical concepts better than text-based learning alone. In the PBL model, students are actively involved in solving the problems or cases they face. They receive information from the teacher and must find solutions by collaborating in groups. Statistics board tools facilitate discussion and collaborative problem-solving among students, which can enhance their understanding by exchanging ideas and points of view.

In PBL, students are given real problems or cases that require the application of statistical concepts to solve them. Using statistics board tools, they can directly apply the concepts they have learned in real situations. This helps students see statistical concepts' relevance and practical application, increasing their learning motivation. PBL encourages students to take an active role in their learning. They must identify problems, collect data, analyze information, and develop solutions independently or in groups. Statistics board tools provide a clear visual framework to support this learning process, making students feel more confident in tackling statistical challenges.

5. Conclusion

This research shows a significant difference in the problem-solving abilities of Madrasah Tsanawiyah (MTs) students when using the problem-based learning (PBL) model with the support of teaching aids compared to other learning approaches. The research results show that the consistent use of the PBL model with teaching aids can improve students' problem-solving ability. Therefore, this research recommends using learning media that uses the PBL model and teaching aids in the learning process at MTs. This is due to empirical evidence showing that this learning approach effectively improves students' problem-solving abilities at the Madrasah Tsanawiyah level. Thus, using learning media that integrates the PBL model and teaching aids can be an effective strategy for improving the quality of learning at MTs.

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