

The Effectiveness of the Problem-Based Learning Model Based on Open-Ended To Improve Mathematical Creative Thinking Skills

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Received June 8, 2023

Accepted June 28, 2023

Published July 5, 2023

Abstract: The ability to think mathematically creative students is very important in mathematics teaching. Students' mathematical creative thinking ability is still relatively low can be seen from various factors. This study aims to find out how the implementation of a Problem-Based learning model based on open-ended to improve students' mathematical creative thinking skills, and to determine the effectiveness of a Problem-Based learning model based on open-ended to improve students' mathematical creative thinking skills. This type of research is quantitative research with experimental methods. The population in this study were all grade VIII MTs N 1 Purbalingga students. The sample of this research was the students of grades VIII G and VIII H with sampling techniques using Convenience Sampling. The instruments used in this study were pre-test and post-test description questions with data analysis using the T-test. Based on the research, it can be concluded that the implementation of the learning model based on open-ended is conducted very well, with an observer score of 3.46. From the results of the T-test data analysis, it can be seen that the learning model based on open-ended is effective for improving students' mathematical creative thinking skills, it can be seen from the significance value of $0.006 < 0.05$, then H_0 is rejected and H_1 is accepted, which means that the problem-based learning model based on open-ended effective to improve students' mathematical creative thinking skills.

Keywords: Problem-Based Learning model; Open-Ended Approach; Mathematical Creative Thinking Ability.

A. Introduction

Education is a conscious and planned effort as an effort to promote ethics, mind and body in order to promote better perfection in life. According to Law No. 20 of 2003, education is a conscious and planned effort that aims to create a learning atmosphere and the learning process of students actively developing their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation, and state.

Educational Objectives are very important in an education, because the purpose of Education is the direction to be aimed or to be achieved in an Education. Therefore, the purpose of education always changes from time to time which is adjusted to the demands of development and development of the lives of the people and the state of Indonesia.

Mathematics is a scientific discipline that systematically examines mindsets, relationship patterns, language, and art which are all studied with logic and are deductive, mathematics can

be useful in helping humans in social, economic, and natural problems. Mathematics is one of the subjects that is considered important to teach because mathematics will require students to think logically, thoroughly, and calculatingly which is useful in everyday life.

The ability to think higher order is a component of thinking ability, which is the ability to process the mind to produce new ideas. According to Beetlestone (1998), the creative aspect of the brain can help explain and interpret abstract concepts, thus allowing students to achieve greater mastery, especially in subjects such as mathematics and science that are often difficult to understand. Thus, it can be concluded that students' creative thinking is one of the aspects that plays a role in improving students' mathematical creative thinking skills in the field of mathematics.

Many efforts have been made by the government to develop students' creative thinking skills. One of them is in K-13, the government requires that in every learning process must support students to improve students' mathematical creative thinking skills. This is illustrated in the principles of k-13 learning (Permendikbud No. 103, 2014). In 2018 the government presented HOTS type questions of 10% in UN questions, the policy was implemented to train students to use their skills to think creatively and critically. In addition, government policy also aims to encourage teachers to improve the quality of learning in the classroom.

Indonesia's participation in PISA since 2000 also aims to evaluate and improve the quality of education with students' reading literacy skills, mathematics skills and science skills in 2015. However, the efforts made by the government have not been directly proportional to the results achieved to improve students' mathematical creative thinking skills. The latest PISA results in 2015 did increase from 275 points in 2012 to 386 points in 2015. However, Indonesia is still in the bottom position, inferior to neighboring countries and even lagging far behind Singapore which occupies the first position.

In the participation of TIMSS (Trends In International Mathematics And Science Study) which aims to evaluate and improve the quality of mathematics and science education in Indonesia. However, the efforts made by the government are still not directly proportional to the purpose of participation in TIMSS. This can be seen from the average mathematics achievement score in Indonesia for 3 periods (1999, 2003-2007, 2011, and 2015) is still low which shows that in general students in Indonesia only know concepts and cannot apply concepts in various problems well in mathematics. So that students can only solve the exact same questions exemplified by the teacher.

Another indicator that illustrates the weakness of students' mathematical creative thinking skills can be seen from the results of UN mathematics subjects are in the less category. In fact, in general, the UN results of each level have decreased from 2014/2015 to 2017/2018. One of the causes of the decline in UN results is allegedly because the implementation of UNBK has many HOTS questions, where there are many HOTS questions that require reasoning in solving so that it requires students to think more creatively in solving these problems. thus making the difficulty level of the questions higher.

In the ability to think creatively, students are required to be more independent and active in learning. However, now a lot of classroom learning only relies on the teacher, so students are less active and what happens is that students become passive in the learning process. Based on the results of interviews with teaching teachers in class VIII mathematics subjects at MTs N 1 Purbalingga, it is known that students' mathematical creative thinking skills are still low.

It can be seen from the results of students' tests and assignments, most of the answers from students are still ordinary or less varied in answering questions. Students tend to be lazy to solve questions independently, there are no students who ask questions about other ways to solve or solve problems so that students always answer questions in the way the teacher has taught, there is no desire to solve problems with their own thoughts in various ways.

To overcome these problems, an Open-Ended Problem Based Learning model can be applied, where the learning model offers a form of learning that involves students actively in their learning so that students are more creative in solving open-ended based mathematical problems. Where the learning model strongly emphasizes students to be more independent in learning so that students can build their own knowledge, and can create a conducive and fun classroom atmosphere so that students can learn actively and are able to solve mathematical problems related to a problem.

Based on the statements above, researchers are interested in conducting research entitled *The Effectiveness of Open-Ended Based Learning Problem Based Models to Improve Mathematical Creative Thinking Skills of Class VIII Mts N 1 Purbalingga Students.*

B. Methods

The type of research in this study is quantitative research. Quantitative research refers to the philosophical view of positivism which views that phenomena in research can be classified, measurable, relatively fixed, concrete, observed, and have a relationship of symptoms that are cause and effect. Quantitative research method is a type of research whose specifics are more planned, systematic, and structured more clearly from the beginning to the end of the research. As for those who consider that quantitative research is a study that uses numbers, starting from data collection, interpretation of the data obtained, and the appearance of the results.

The research design used in the study was the Pretest and Posttest Control Group. The research began with the provision of Pretest to the experimental class and the control class, then given mathematics learning to the experimental class using the problem based learning models base on open-ended and the control class using conventional model. After carrying out the entire series of learning, the two classes were given a posttest with the aim of determining the improvement of students mathematical creative thinking skills.

This research was conducted at MTs N 1 Purbalingga located on Jl. Sokawera No. 01, Karanganyar Village, Karanganyar District, Purbalingga Regency, Central Java Province 53354. The learning process carried out for this research was carried out in classes VIII G and VIII H as control classes and experimental classes.

The population is the overall subject of study. If one wants to examine all the elements in the research area, then the research is population research. Stidu or its research is also called population study or census study. The population of this study was MTs N 1 Purbalingga Class VIII students totaling 320 students.

The sample is a portion or representative of the population studied. The sample is also part of the number and character possessed by that population. If the population is large, and it is not possible to study everything in the population, for example due to limited funds, energy and time, then the study can use samples taken from that population. The sample of this study

uses the Convenience Sampling Technique, which is sampling where researchers choose participants because they are willing to be studied. In this case, the researcher cannot say with confidence that the individual is representative of the population. However, samples can provide useful information to answer questions and hypotheses. The samples used in this study were class VIII G numbering 28 and class VIII H totaling 30 students.

The method of collecting data in this study is using observation and tests. Data collection techniques with observation are used when the research deals with human behavior, work processes, natural phenomena and when the observed respondents are not large.

In this case, observations were used to obtain data to see the implementation of open-ended based problem based learning (PBL) models to improve the mathematical creative thinking skills of grade VIII MTs N 1 Purbalingga students. The instrument used to observe the implementation is with an observation sheet assessed by the class teacher and one other observer.

Then to increase the ability of researchers in teaching is calculated by adding up the total score then divided into many aspects in the observation sheet. The following are the basic decision-making guidelines for the implementation of the Problem Based Learning mode base on Open-Ended:

Table 1. Implementation Decision Making Guidelines

Average Score	Implementation Descriptin
$3,25 \leq x \leq 4,00$	Very Good
$2,50 \leq x \leq 3,25$	Good
$1,75 \leq x \leq 2,50$	Good Enough
$1,00 \leq x \leq 1,75$	Not Good

Then to measure the effectiveness of open-ended based problem-based learning models to improve creative thinking skills Student mathematics can be done if they have been given treatment to the experimental group. After being given treatment, researchers will get the data needed to analyze the data. The data will be analyzed using the T test (hypothesis) with the help of SPSS version 16.

The criteria used in the T test are as follows:

If H_0 is accepted if the value of $t_{\text{count}} \leq t_{\text{table}}$, or the value of sig (2-tailed) $> \alpha$

If H_1 is accepted if the value of $t_{\text{count}} \geq t_{\text{table}}$ or the value of sig (2-tailed) $< \alpha$

If there is acceptance of H_0 , it can be concluded that there is no significant effect, while if H_0 is rejected it means that there is a significant influence. Which means that if H_0 is accepted, it means that there is no effectiveness of the Problem Based Learning Model base on open-ended to improve the mathematical creative thinking ability of grade VIII Mts N 1 Purbalingga students.

To improve the mathematical creative thinking ability of grade VIII students of Mts N 1 Purbalingga. And if H_1 is accepted , it means that there is an effectiveness of the open-ended based Problem Based learning model base on open-ended to improve the mathematical creative thinking ability of grade VIII Mts N 1 Purbalingga students.

C. Results and Discussion

1. Implementation data analysis

In this implementation data analysis, it will be explained how to implement an open-ended problem-based learning model on experimental class statistics material. The implementation data was taken from an observation sheet given to two observers, namely Azwar Usman, S.Pd and Inanda Shofa Azahroh. The following are the results of implementation observations filled in by observers:

Table 2. Implementation Observations

No	Observers	Date Of Observation	Total Score	Average Observer Score
1	Observer 1	Thursday, 11 May 2023	46	3,54
2	Observer 2	Thursday, 11 May 2023	44	3,38
Observation Score Results			90	6,92
Averange Observation Score Results			45	3,46

Based on the table above, it can be seen that the observation score obtained from the implementation observations by Azwar Usman, S.Pd. and Inanda Shofa Azahroh is 3.46. Based on the decision-making guidelines in table 3. 9, a score of 3.46 falls into the "Very Good" category. Thus, it can be said that the implementation of problem based learning models base on open-ended in experimental class statistics material is very good.

2. Effectiveness Data Analysis

After the pretest and posstest instruments are tested for validity and reliability, the pretest and posstest can be used to determine the effectiveness of implementation of problem based learning models base on open-ended to improve the mathematical creative thinking skills of grade VIII MTs N 1 Purbalingga students. The following is an analysis of pretest and posstest data after being applied to experimental classes and control classes to determine the effectiveness of problem based learning models base on open-ended to improve mathematical creative thinking skills:

a. Pretest Data Analysis

Pretest is used to measure students' initial ability related to mathematical communication skills before different learning models or treatments are carried out. The following are the pretest results in the experimental class and control class.

Table 3. Pretest Value Comparison Experiment Class and Control Class

No	Experiment Class Code	Pretest Scores	Control Class Code	Peretest Score
1	A1	45	B1	45
2	A2	55	B2	55
3	A3	44	B3	44
4	A4	45	B4	46
5	A5	57	B5	47
6	A6	36	B6	36
7	A7	43	B7	43
8	A8	45	B8	44

9	A9	45	B9	45
10	A10	39	B10	38
11	A11	44	B11	44
12	A12	57	B12	47
13	A13	54	B13	55
14	A14	35	B14	46
15	A15	57	B15	42
16	A16	47	B16	33
17	A17	44	B17	44
18	A18	55	B18	49
19	A19	48	B19	48
20	A20	45	B20	41
21	A21	55	B21	46
22	A22	48	B22	49
23	A23	36	B23	33
24	A24	38	B24	47
25	A25	35	B25	38
26	A26	47	B26	47
27	A27	35	B27	39
28	A28	38	B28	55
29	A29	58	-	-
30	A30	45	-	-
Sum		1375	Sum	1246
Average		45.83	Average	44.5
Highest Score		58	Highest Score	55
Lowest Score		35	Lowest Score	33

Based on the table above, it can be seen that the lowest scores of the two classes are different, namely 35 and 33, the highest scores of the two classes are also different, namely for experimental class 58 control class 55, and for the average of the two classes are almost the same at 45.83 and 44.5. So it can be said that the creative thinking ability of experimental class students and control classes is the same, and problem based learning models based on open-ended can be applied to experimental classes.

The normality test is a procedure used to determine whether data is normally distributed or not. Test normality using Kolmogorov Smirnov's formula. Results of data analysis using SPSS Version 16 software.

The decision-making guideline in the test is that if the significance number of the Kolmogorov Smirnov Sig. test ≥ 0.05 , then the data distributes normally and if the significance number of the Kolmogorov Smirnov Sig. test < 0.05 , which means that the data does not distribute normally. Here are the results of the experimental class and control class pretest normality tests:

Table 4. Pretest Normality Results

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Hasil	.112	58	.069	.946	58	.062

a. Lilliefors Significance Correction

Based on the table above, it can be seen that the significance value of the experimental class is $0,69 > 0.050$. So it can be concluded that the pretest results of the two classes are normal

A homogeneity test is performed to find out if the sample comes from a population that has the same variance. A homogeneity test can be performed when the data group is normally distributed.

The decision-making guideline in the test is if the homogeneous test significance number ≥ 0.05 which means homogeneous data and if the homogeneous test significance number < 0.05 which means the data is not homogeneous. In this study, the homogeneity test was carried out using the SPSS Version 16 software application. Here are the homogeneity test results from the pretest data:

Table 5. Pretest Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	2.253	1	56	.139
	Based on Median	1.730	1	56	.194
	Based on Median and with adjusted df	1.730	1	53.970	.194
	Based on trimmed mean	2.221	1	56	.142

Based on the results of the homogeneity test according to the table above, it shows that the significance value (Sig) Based on Mean is $0.139 > 0.050$, so it can be concluded that the variant of pretest data for the experimental class and the control class is homogeneous (the same).

The T test is performed after it is known that the data taken is normally distributed data. Then, to test the hypothesis in this study using an independent sample t test using SPSS Version 16 software. This hypothesis test was conducted to determine whether there is an effectiveness of problem based learning models base on open-ended to improve students' mathematical creative thinking skills. The results of the independent sample T test conducted using SPSS Version 16 software are as follows

Table 6. Results of the hypothesis test Independent Samples Test

		Levene's Test for Equality of Variances			t-test for Equality of Means					
		F	Sig.	T	df	Sig. (2- taile d)	Mean Differ ence	Std. Error Differ ence	95% Confidence Interval of the Difference	
									Lower	Upper
Hasil	Equal variances assumed	2.253	.139	.763	56	.449	1.333	1.748	-2.169	4.836
	Equal variances not assumed			.769	54.21 6	.445	1.333	1.733	-2.141	4.808

Based on the results of the independent sample t test using SPSS Version 16 software above, it can be seen that the value of sig. (2-tailed) $0.449 > 0.05$, then H_0 accepted and H_1 rejected. This shows that the scores of the experimental class and the control class were not significantly different. : It can be interpreted that conventional learning models (lectures) have no effect on the ability to understand mathematical concepts.

b. Posttest Data Analysis

Posttest is used to measure students' final ability related to mathematical communication skills after different learning models or treatments in experimental and control classes. Here are the posttest results in the experimental class and control class:

Table 7. Comparison of Experimental Class and Control Class Pretest Values

No	Experiment Class Code	Pretest Scores	Control Class Code	Pretest Scores
1	A1	76	B1	75
2	A2	79	B2	80
3	A3	74	B3	70
4	A4	72	B4	65
5	A5	95	B5	67
6	A6	78	B6	80
7	A7	92	B7	78
8	A8	85	B8	79
9	A9	75	B9	75
10	A10	90	B10	68
11	A11	86	B11	75
12	A12	90	B12	78
13	A13	78	B13	79
14	A14	90	B14	67
15	A15	88	B15	79
16	A16	79	B16	82
17	A17	80	B17	75
18	A18	79	B18	85
19	A19	70	B19	74
20	A20	75	B20	72
21	A21	80	B21	80
22	A22	85	B22	74
23	A23	75	B23	80
24	A24	91	B24	65
25	A25	75	B25	65
26	A26	74	B26	82
27	A27	68	B27	80

28	A28	92	B28	75
29	A29	67		
30	A30	72		
Sum		2410	Sum	2104
Average		80.5	Average	75.5
Highest Score		95	Highest Score	85
Lowest Score		67	Lowest Score	65

Based on the table above, it can be seen that the lowest scores of the two classes are not the same, namely for the experimental class of 67 and the control value of 65, the highest values of the two classes are different, namely for experimental class 95, control class 85, and for the average of the two classes are also different, namely 80.5 for experimental class and 75.5 for control class. So it can be said that the mathematical creative thinking ability of experimental class and control class students is different, where the posttest results of the experimental class are higher than those of the control class.

The normality test is a procedure used to determine whether data is normally distributed or not. Test normality using Kolmogorov Smirnov's formula. Results of data analysis using SPSS Version 16 software.

The decision-making guideline in the test is that if the significance number of the Kolmogorov Smirnov Sig. test ≥ 0.05 , then the data distributes normally and if the significance number of the Kolmogorov Smirnov Sig. test < 0.05 , which means that the data does not distribute normally. Here are the results of the experimental class and control class pretest normality tests:

Based on the table above, it can be seen that the significance value of the experimen class is $0.093 > 0.050$. So it can be concluded that the posttest results of both classes are normal.

A homogeneity test is performed to find out if the sample comes from a population that has the same variance. A homogeneity test can be performed when the data group is normally distributed.

The decision-making guideline in the test is if the homogeneous test significance number ≥ 0.05 which means homogeneous data and if the homogeneous test significance number < 0.05 which means the data is not homogeneous. In this study, the homogeneity test was carried out using the SPSS Version 16 software application. Here are the homogeneity test results from the posttest date:

Table 9. Posttest homogeneity test results

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	4.345	1	56	.042
	Based on Median	2.939	1	56	.092
	Based on Median and with adjusted df	2.939	1	50.967	.093
	Based on trimmed mean	4.268	1	56	.043

Based on the results of the homogeneity test according to the table above, it shows that the significance value (Sig) Based on Mean is $0.042 < 0.050$, so it can be concluded that the posttest data variant of the experimental class and the control class is not homogeneous (not

the same).

The T test is performed after it is known that the data taken is normally distributed data. Then, to test the hypothesis in this study using an independent sample t test using SPSS Version 16 software. This hypothesis test was conducted to determine whether there is an effectiveness of problem based learning models base on pen-ended to improve students' mathematical creative thinking skills. The results of the independent sample posttest T test conducted using SPSS Version 16 software are as follows:

Table 10 Results of the hypothesis test (independent samples t test) on the posttest question

		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
Hasil	Equal variances assumed	4.345	0.42	2.833	56	.006	5.190	1.832	1.520	8.860
	Equal variances not assumed			2.864	52.986	.006	5.190	1.812	1.555	8.826

Based on the results of the independent sample t test using SPSS Version 16 software above, it can be seen that the value of sig. (2-tailed) $0.006 < 0.05$, then H_0 rejected and H_1 Accepted. This shows that the scores of the experimental class and the control class are significantly different. : It can be interpreted that problem based learning models base on pen-ended are effective for improving students' mathematical creative thinking skills.

D. Conclusion

Based on research and discussion, it can be concluded that problem based learning models base on open-ended can be done well, in accordance with the research criteria table and obtained an average of 3.46 which means that it is vulnerable $3.25 \leq X \leq 4.00$, so it is included in the "Very Good" category. So it can be said that the implementation of problem based learning models base on open-ended on experimental class statistics material is very good.

The problem based learning models base on open-ended is effective for improving the mathematical creative thinking skills of grade VIII students. Evidenced by showing that the score scores of the experimental class and the control class were significantly different. And also seen from the results of the t test with a significance value (2-tailed) of $0.006 < 0.05$, H_0 was rejected and H_1 was accepted, which means that the problem based learning models base on open-ended is effective for improving the mathematical creative thinking ability of grade VIII MTs N 1 Purbalingga students.

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