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A Comparative Study on Critical Thinking of Mathematical Problem Solving Using Problem Based Learning and Direct Intruction

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***Abstract* —** This research aims to determine and compare the impact of the application of problem-based learning and direct instruction on students' critical thinking skills in solving mathematical problems. This research is quantitative research with a quasi-experimental research type. This study is the Nonequivalent Control Group Design. The population in this research was the elementary school students at grade V SDN 113 Inpres Laikang and the sample of the research consisted of two classes that were selected based on purposive sampling techniques. Test and questionnaire were used to collect the data and they were analyzed by using normality test, homogeneity test, and t-test. The results showed that the application of problem-based learning has a better positive effect than the application of direct instruction on students' critical thinking ability in solving mathematical problems.

***Keywords* —** problem based learning, critical thinking ability, mathematical problem solving

I. INTRODUCTION

The 2013 curriculum is designed to produce a human being productive, innovative, and able to develop their thinking in the realm of high-level thinking [1]. The objectives of the 2013 curriculum are in accordance with the objectives of mathematics learning. According to Magfirah [2], mathematics is a field of science that is taught from the elementary level to higher education. Moreover, mathematics is a basic science that becomes the foundation of various other disciplines [3]. Some of the objectives of mathematics education at the level of primary and secondary education are: (1) preparing students to be able to face the changing circumstances in real life that always change, through the practice of acting on the basis of logical, rational, critical, careful, effective, efficient thinking, and honestly, (2) preparing students to be able to use mathematics and mathematical mindset in daily life and in learning various sciences. Critical, logical, and rational thinking as well as the ability to solve problems are among the 21st-century skills that must be possessed by every student [4].

Based on the learning objectives of mathematics above, it should be considered that learning mathematics in school should be intended as a means to train high-level mindset of students, such as their critical thinking skills. It shows that critical thinking ability is a competency that must be possessed by every student and it is very important to be developed by students.

Every student must develop their critical thinking ability and one of them is through answering problem-solving questions related to Mathematics. Handriana [5] explains that problem solving helps think critically, creatively, and develop other mathematical abilities.

Siswono [6] stated that besides giving problem-solving questions, there is another strategy that can be used to develop students' critical thinking skills, and it is by applying a problem-based learning model. According to Kaharuddin, [7] the problem-based learning model is an innovation in learning because in the problem-based learning model students' thinking abilities are optimized through systematic group or teamwork processes so that students can empower, analyze, test, and develop the ability to think sustainably.

Pereira, Hastie, Araujo, Farias, Colim, & Mesuita [8] state that direct instruction is a learning approach that emphasizes the discovery of highly structured factual information and knowledge. Direct instruction is an innovation of traditional learning that are still effective for teaching concepts and skills that are explicit to students who are underachieving. It becomes the focus and attention of mathematics education because it is related to the characteristics, nature, and skills of students.

There are five aspects of critical thinking skills, namely: (1) Elementary clarification (providing basic explanation), (2) The basis for the decision (determining the basis for decision making), (3) Inference (drawing conclusions), (4) Advanced clarification (providing further explanation), and (5) Supposition and integration (estimating and combining)

[8]. According to Ismail [9], if students can fulfill the three indicators of the five indicators of critical thinking, it can be classified that students are able to think critically. The three indicators are: (1) Elementary clarification (providing basic explanation); (2) skills in recognizing and solving problems; (3) Inference (drawing conclusions).

II. METHOD

This research is quantitative research with quasi-experimental research type. This research was conducted in February 2019. The research location was at SDN 113 Inpres Laikang. The population in this study was all fifth-grade students of SDN 113 Inpres Laikang. The sample in this study was two classes, one as experimental class and another one as control class. The sampling technique was based on a purposive sampling technique with the research design using the Nonequivalent Post Test-Only Control Group Design.

TABLE I. RESEADCH DESIGN

Random	Treatment	*Post test*
Problem based learning	X_1	O
Direct instruction	X_2	O

Information:
X1 = Treatment that is applied to problem based learning
X2 = Treatment that is applied to direct instruction
O = Post test

By applying the purposive sampling technique, it is found that the first class was given treatment (X1) and the second class was given treatment (X2). The both classes were given post-test (O) to know their critical thinking skills in solving the mathematical problem. The ability to think critically in problem solving based on indicators of critical thinking is presented in the following Table 2.

TABLE II. INDICATORS OF CRITICAL THINKING ABILITY

The Measured Aspects	**Student Responses to Questions**
Elementary clarification (providing basic explanation)	In solving mathematical problems students must provide a complete mathematical reason in the question before students decide to choose the right strategy or procedure.
Skills in Recognizing and Solving Problems	The applicative skills of the concept to several definitions. Students can choose the right step, implement the procedures (arithmetic operations), and the sequential completion of coherent according to problem solving.
Inference (drawing conclusions)	The drawing of correct conclusion should be based on steps from reasons to logical conclusions and students can write the conclusions correctly.

Validation instrument analysis is used to determine the accuracy of a question, and the product moment formula is used [10]:

$$r_{xy} = \frac{N.(\sum XY) - (\sum X)(\sum Y)}{\sqrt{\{N.\sum X^2 - (\sum X)^2\}\{N.\sum Y^2 - (\sum Y)^2\}}}$$

Information:
r_{xy} : The correlation coefficient between the score of items (X) and the total score (Y)
N : Many subjects
X : Item score or statement item / question score
Y : Total score

The Alpha formula is used to determine the reliability of the instrument and the results of testing the instrument [11]:

$$r_{11} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum \delta_b{}^2}{\delta_t{}^2}\right)$$

Information:

r_{11} : Instrument reliability
k : The number of the questions
Σd_b^2 : Number of the item variances
$d_t{}^2$: Total Variance

Furthermore, based on the prerequisite analysis test, it was found that the two data groups were normally distributed and the data were not homogenous. So, the hypothesis test used was t-test, which is formulated:

$$t'_{hitung} = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1{}^2}{n_1} + \frac{s_2{}^2}{n_2}}}$$

Information:
$\overline{X_1}$ = The average critical thinking skills of students using problem based learning models.
$\overline{X_2}$ = The average critical thinking skills of students using conventional teaching.
$s_1{}^2$ = Variance of students' critical thinking abilities using problem based learning models.
$s_2{}^2$ = Variance of students' critical thinking abilities using conventional learning.
n_1 = The number of students taught by using problem based learning models.
n_2 = The number of students taught using conventional learning.

The critical value

$$t'_{\alpha} = \frac{\frac{(t_1 s_1{}^2)}{n_1} + \frac{(t_2 s_2{}^2)}{n_2}}{\frac{s_1{}^2}{n_1} + \frac{s_2{}^2}{n_2}}$$

Information:

$t_1 = t(a, n_1 - 1)$
$t_2 = t(a, n_2 - 1)$

III. RESULT AND DISCUSSION

After the post test was conducted, descriptive data on critical thinking abilities in problem solving in experimental class 1 and experimental class 2 were presented in the table 3:

TABLE III. DESCRIPTION OF THE CRITICAL THINKING ABILITY IN PROBLEM SOLVING FOR EXPERIMENT CLASS 1 AND EXPERIMENT CLASS 2

STATISTICS	**EXPERIMENT CLASS 1**	**EXPERIMENT CLASS 2**
N	36	38
AVERAGE	51	36
STANDARD DEVIATION	9,8	6,8
VARIANCE	96,9	45,7
MAXIMUM	75	48
MINIMUM	40	23

Table 3 shows that the description of students' critical thinking ability in solving mathematical problems from the application of problem-based learning has higher positive effect than the application of direct instruction. It is shown that the average value of students' critical thinking skills in solving mathematical problems in the experimental class 1 is 51 higher than the average value of students' critical thinking skills in solving mathematical problems in the experimental class 2 is 36. Another thing is also seen from the significance value of the standard deviation, variance, maximum and minimum value obtained by the experimental class 1 is higher than the value of the experimental class 2.

After the t-test was done it was seen that $t'_{hitung} = 7{,}664 > t'_{a} = 2{,}029$ on $a = 0{,}05$. Based on testing criteria of t-test ', H0 is not accepted and it means that an average of critical thinking ability in problem-solving in the experimental class was higher than the average of critical thinking ability in problem-solving in the control class.

Based on the results obtained of the post-test, it was found that the students' ability of critical thinking in solving mathematical problems after applying problem-based learning is 51, the class average score, which is classified as moderate with the minimum score 40 and the maximum score 75. It shows that the problem based learning has a positive impact on the critical thinking ability in problem solving that is seen from the achievements obtained by the experimental class 1 with an average in the moderate category. After post-test is given, the hypothesis test was conducted to determine the results of whether the problem based learning model has a positive impact on critical thinking ability in problem solving or not. Hypothesis testing used is the t-test.

Based on the results obtained of the post-test, it was found that the students' ability of critical thinking in solving mathematical problems after applying direct instruction is 36, the class average score, which is classified as low with the minimum score 23 and the maximum score 48. It shows that the direct instruction has less positive impact on the students' critical thinking ability in solving mathematical problems that is seen from the achievements obtained by the experimental class 2 with an average in the low category. After post-test is given, the hypothesis test was conducted to determine the results of whether the direct instruction model has less positive impact on students' critical thinking ability in solving mathematical problems or not. Hypothesis testing used is the t-test.

Based on the hypothesis testing conducted, it was obtained significance value with a significant level = 0.05. Based on the testing criteria, it was obtained that the experimental class 1 had a significant positive effect on the application of the problem-based learning model to the students' critical thinking ability in solving mathematical problems rather than the experimental class 2. Or it can be said that there is a positive effect of the application of problem-based learning on students' critical thinking ability in solving mathematical problems.

The results of this study are supported by the results of Kaharuddin's research that the model of Problem Based Learning is better than the learning model that emphasizes on skill because problem based learning is a learning model that emphasizes on students' thinking ability. Thus, in this study also explained that in the aspect of problem based learning, students are able to construct their own knowledge from the real problems given. It is different with direct instruction in which the teacher provides guidance solution to the problem. Therefore, it can be concluded descriptively and inferentially that problem based learning is better than direct instruction.

IV. Conclusion

Based on the results of research and discussion in this study, it can be concluded that the application of problem based learning has more positive effect than direct instruction in terms of critical thinking ability in solving mathematical problems at the fifth grade students of elementary school.

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