



Effectiveness of Mathematical Learning Model to Stimulate Critical Thinking on Mathematics Learning Outcomes of High School Students

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Abstract

This study aims to determine the effectiveness of the mathematics learning model to stimulate critical thinking on student mathematics learning outcomes compared to the direct learning model in class XII science students of senior high school in Pacitan. The type of research is quasi-experimental, with a population of all students of class XII IPA of SMA N 2 Pacitan. The sample consists of 28 students of class XII IPA-1 as an experimental class and class XII of IPA-2 of 28 students as a control class. The sampling technique was purposive random sampling. Data collection techniques using the test. The test is a student's initial ability test and a student's mathematics learning outcomes test. The analysis technique of the data used in this study is the t-test, while the analysis of prerequisite tests includes tests of normality and homogeneity tests. The results showed that mathematics learning using the mathematics learning model to stimulate critical thinking was more effectively applied in learning compared to the direct learning model of the mathematics learning outcomes of high school students in terms of the results of the t-test analysis and the average test scores of learning outcomes.

Keywords: effectiveness, critical thinking, mathematical learning model, learning outcomes

INTRODUCTION

Quality human resources is an important factor in development in the era of globalization. Experience in many countries shows that quality human resources are more important than abundant natural resources. Quality human resources can only be realized with quality education (Tjalla, 2008). Therefore, efforts to improve the quality of education are non-negotiable in the context of improving the quality of Indonesia's human resources.

Education has an important role in a nation. Education must be developed continuously following the times. Through education, it is hoped that the Indonesian people can improve the quality of education. The quality of education is closely related to the learning process because the learning process is one of the most important aspects of education. Quality education shall lead

students to achieve the functions and goals of education. The function of national education as contained in Undang-undang Number 20 of the year 2003 pasal 3 is to develop capabilities and shape the character and civilization of a dignified nation in order to educate the life of the nation, aiming to develop the potential of students to become human beings who believe in and devote to God, noble, healthy, knowledgeable, capable, creative, independent and become citizens of a democratic and responsible.

Education is a systematic process to enhance human dignity holistically. This can be seen from the philosophy of education which is essential to actualize the three most elementary dimensions of humanity, namely: (1) affective which is reflected in the quality of faith and piety, ethics and aesthetics, as well as noble character and noble character; (2) cognitive which is reflected in the capacity of

thought and intellectual power to explore knowledge and develop and master the technology; and (3) psychomotor which is reflected in the ability to develop technical skills and practical skills (Depdiknas, 2005, p. 23). All of this boils down to how to prepare students to be able to live life with fun (preparing students for life with enjoy), and not just prepare students to be human beings who only live life without enthusiasm. Education, in this case, becomes a strategic vehicle for teachers in an effort to develop the full potential of the next generation of qualified candidates. Education, in this case, aims to help students to be able to glorify life (ennobling life).

In fact, students do not have the ability to think at a high level, including critical thinking skills, the ability to reason, and strategic competence, by utilizing the material they understand. This is one of the weaknesses of the results of learning mathematics in Indonesia. The ability to think at a higher level or first preceded by the term High Order Mathematical Thinking (HOMT) was not optimally developed (Dahlan, 2012, p. 66). As a result, Indonesian students are weak when they have to think critically to identify new problems, search for and develop materials/ ideas to solve them, let alone have to flexibly use settlement procedures. From a variety of higher-level thinking skills, there are significant difficulties including when they have to think critically.

Ennis (1996, p. 364) explains critical thinking is a process that aims so that we can make decisions that make sense so that what we think is best about a truth we can do correctly. Critical thinking is an important skill needed by students to be able to improve their ability to make judgments while also being able to inform them well, be able to explain their reasons and be able to solve unknown problems (Facione, 2010; Fagin, et al., 2006; Moore, 2004). In line with this statement, Scriven & Paul (2004); Masek & Yamin (2012) mentioned that critical thinking is the ability to analyze and evaluate information and

ask important questions. Critical thinking causes arguments and conclusions that are valid, strong, and resistant to criticism (Onions, 2009, p. 2).

The ability to think critically is very important for students at every level of education. This is following the priorities of educational development stated in the curriculum where students are expected to be able to think mathematically, namely thinking logically, analytically, systematically, critically, creatively, and the ability to work together (Lambertus, 2009, p. 136).

To overcome the problem of students' low critical thinking skills, Setiana (2018, p. 59-60) in his previous research has developed a learning model called the mathematics learning model to stimulate critical thinking. The learning model has several stages, namely: (1) provide a simple explanation (elementary clarification), contains focusing questions, analyzing questions and asking questions, and answering questions about an explanation or statement; (2) building basic skills (basic support), consists of considering whether the source can be trusted or not and considers an observation report; (3) summing up (interference), consists of reducing or considering the results of deduction, inducing or considering the results of induction, and making and determining the value of the consideration; (4) provide advanced clarification, consists of identifying terms and definitions and considerations as well as dimensions, and identifying assumptions; and (5) manage strategy and tactics (strategy and tactics), consists of determining actions and interacting with others. Furthermore, Setiana (2018) suggested that the stages of the learning model were combined with stimulation stages in the form of a) reinforcement, b) module usage, c) test provision, d) student activity, e) no punishment, f) direction, g) giving feedback.

Setiana (2018, p. 62) the occurrence of critical thinking in learning mathematics is to present non-routine and open-ended context problems both individually and in groups by

utilizing students' initial knowledge. This, in line with the opinion of Romberg (1995, p. 51) which says that to build critical thinking in student learning needs to be faced with contradictory and new problems so that he constructs his mind in search of truth and clear reasons.

Mathematical learning models to stimulate critical thinking are developed in the form of integrated learning, therefore critical thinking appears in learning activities as well as learning targets. The stages of stimulation of critical thinking based on the Theory of Operant Conditioning by Skinner. The theory emphasizes the existence of reinforcement, both positive and negative reinforcement (Smith, et al., 2009, p. 82). The main critical thinking theory used in this research is the development of critical thinking put forward by Ennis (1996, p. 364) through six elements of critical thinking which are synchronized into FRISCO (Focus, Reason, Inference, Situation, Clarify, and Overview). Other theories that are also applied are Bloom's Taxonomy which contains six stages of thinking, namely: (1) remember; (2) understand; (3) apply; (4) analyze; (5) evaluate; and (6) create (Bloom, 1956; Anderson & Krathwohl, 2001, p. 66-88).

Fink's Theory (2003) which contains five steps to change students towards critical thinking and Potts and Bonnie's Theory (1994) regarding the characteristics of critical thinking learning is also referred to in this paper. These theories are adapted into the learning activities contained in the lesson plan include the stages of remembering, understanding, applying, analyzing, and evaluating. The preparation of questions in the worksheet and tests used Krulik and Rudnick's Theory (1994) regarding the development of students' critical thinking skills through answering innovative questions.

Unlike the mathematics learning model to stimulate critical thinking, the direct learning model is a teaching approach model that can help students learn and master basic skills and obtain information step by step. In other words, this direct learning model is a

teacher center which is where the role of the teacher is very dominant, the teacher is required to be able to become an attractive model for students (Fathurrohman, 2017, p. 166).

The dominant learning model used in SMA N 2 Pacitan is a direct learning model. As a result, the critical thinking ability of students at SMA N 2 Pacitan is quite low. This is known based on the results of the initial ability test. The results of students' initial ability tests had an average of 59.42 in the experimental class and 53.5 in the control class. The low average score of students on the initial ability test indicates low critical thinking skills.

Mathematics learning by using a mathematics learning model to stimulate critical thinking will help stimulate students' critical thinking skills. With the ability to think critically students will be able to solve problems effectively (Shakirova, 2007, p. 42; Setiana, et al., 2019, p. 83). With the ability to solve problems such as mathematics learning, it will improve student learning outcomes.

Starting from the previous elaboration, further research was conducted with the aim to find out the effectiveness of the mathematics learning model to stimulate critical thinking on student mathematics learning outcomes compared to the direct learning model in class XII students of SMA N 2 Pacitan.

RESEARCH METHODS

This research is quasi-experimental research (quasi-experiment design). This research was conducted at SMA N 2 Pacitan from November 2016 to January 2017. The population in this study were all students of class XII IPA at SMA N 2 Pacitan odd semester of 2016/2017 academic year. The samples in this study were 28 students in class XII IPA-1 as the experimental class and 28 students in class XII IPA-2 as a control class. Samples were selected by purposive random sampling technique, which is taken with consideration of populations that are considered to have the same ability

(homogeneous). In this study, which acts as an independent variable (X) is a learning model consisting of (X_1), a mathematical learning model to stimulate critical thinking and (X_2) is a direct learning model, and the dependent variable (Y) is the result of learning mathematics.

Retrieval of data using test techniques, namely the students' initial ability test and student learning outcomes test. The student's initial ability test is used to determine the ability possessed by students before being treated and the student's learning outcomes test is used to find out the student's learning outcomes after being given treatment. The research instrument used was a test instrument. The student's initial ability test instrument and student learning outcomes test are essay questions with a total of 5 items. The test instrument is equipped with a grid and scoring guidelines with a total score of 50. The questions used in this test are on Geometry Transformation material. The learning outcomes test is used to determine the mathematics learning outcomes of two class samples, namely a control class that uses a direct learning model and an experimental class that uses a mathematics learning model to stimulate critical thinking.

Mathematical learning model to stimulate critical thinking is said to be effective if the average test score of the learning outcomes is better than the average score of the student's initial ability test and the average value of the experimental class is better than the control class. Besides, another indicator is the percentage of minimum completeness criteria achievement of students in the experimental class is higher than the control class.

The instrument trials include the item validity test and the instrument reliability test. Data analysis techniques in this study include analysis prerequisite tests in the form of normality tests using the Kolmogorov-Smirnov test, homogeneity tests, and hypothesis testing using t-tests. This research hypothesizes that the mathematics learning model to stimulate

critical thinking is more effective than the direct learning model on the learning outcomes of students of class XII IPA in SMA N 2 Pacitan.

RESULTS AND DISCUSSION

Description of Research Results

Descriptions of the learning outcomes of the experimental class and the control class for students' initial ability tests can be seen in Table 1.

Table 1. Description of Preliminary Ability Test Results

No	Description	Class	
		Experiment	Control
1.	Number of students	28	28
2.	Average	59,42	53,5
3.	Max	92	86
4.	Min	30	34
7.	Minimum completeness criteria	2	5
8.	Percentage of completeness	7,1%	17,8%

Description of the experimental class learning outcomes and control classes for student learning outcomes tests can be seen in Table 2.

Table 2. Description of Mathematics Learning Outcomes

No	Description	Class	
		Experiment	Control
1.	Number of students	28	28
2.	Average	84,4	72,9
3.	Max	96	92
4.	Min	70	56
7.	Minimum completeness criteria	24	15
8.	Percentage of completeness	85,7%	53,57%

Prerequisite Test Analysis

Prerequisite test analysis is carried out to find out the balance between the experimental class and the control class which includes the Normality and Homogeneity Tests.

Normality Test

The normality test is carried out using the Kolmogorov-Smirnov test of the SPSS program version 20.0. Data are normally distributed if $\text{sig.} > \alpha$ with a significance level of 0.05.

Table 3. Normality Test of Students' Initial Ability Tests and Student Learning Outcomes Tests

Data	Kolmogorov-Smirnov	
	Standard deviation	Sig. (2-tailed)
Student's initial ability test	9,55089	0,062
Learning outcomes	0,127	0,092

Based on Table 3 for the student's initial ability test gives the results of $\text{Sig.} > 0.05$, that is $0.062 > 0.05$, this means that H_0 is accepted, so it can be concluded that the data come from normally distributed populations. While for student outcomes test, $\text{Sig.} > 0.05$, that is $0.062 > 0.05$, this means that H_0 is accepted, so it can be concluded that the data come from normally distributed populations.

Homogeneity Test

The homogeneity test aims to determine whether the variance of initial ability data and student learning outcome data in both homogeneous classes. Homogeneity test decisions and concluding the hypothesis test performed at a significance level of 0.05.

Table 4. Homogeneity Test Result of Student Initial Ability Test and Learning Outcomes Test

Data	Levene Statistic	
	Levene Statistic	Sig.
Student's initial ability test	0,552	0,462
Learning outcomes	0,015	0,904

Based on Table 4, the homogeneity test results on the initial ability test with $\text{Sig.} 0.462$ and on student learning outcomes obtained $\text{Sig.} 0.904$ with a significance level of 0.05. So both

have $\text{Sig.} > \alpha$, that is $0.462 > 0.05$ and $0.904 > 0.05$, consequently H_0 is accepted. This means that the student's initial ability test data and student learning outcome data for the experimental class and the control class come from a homogeneous population.

Initial Ability Balance Test

An initial ability balance test is performed to find out whether the experimental group and the control group are in a balanced state or not before being treated. With calculations using SPSS 20.0 with the Independent Samples Test obtained Sig. (2-tailed) of 0.713. Because of the value of $\text{Sig.} > 0.05$ which is $0.713 > 0.05$, this means that H_0 is accepted, so it can be concluded that there is no difference in the average initial test scores of students in the experimental class and the control class on learning outcomes. This means that the initial ability tests of students in the experimental class and the control class are balanced.

Hypothesis Testing

The effectiveness of the mathematics learning model to stimulate critical thinking compared to the direct learning model based on student learning outcomes.

Table 5. Summary of T-Test Analysis Results

Data	One-Sample Test	
	Standard deviation	Sig.
Learning Outcomes	16,671	0,000

Based on Table 5, with a significance level of 0.05, the $\text{Sig.} 0,000$ so that the $\text{Sig.} > \alpha$ is $0.05 > 0,000$, consequently H_0 is rejected. This means that the mathematics learning model to stimulate critical thinking is more effectively applied in mathematics learning than the direct learning model of student mathematics learning outcomes.

The effectiveness of the mathematics learning model to stimulate critical thinking compared to the direct learning model based on the percentage of classical completeness.

Table 6. Classical Completion of Experimentation and Control

Class	The average value of learning outcomes	Percentage completeness
Experiment	84,4	85,7%
Control	72,9	53,57%

Based on Table 6, it is found that the percentage of completeness of the experimental class is greater than the percentage of the control class that is 85,7% > 53,57%. So that learning with mathematical learning models to stimulate critical thinking is more effective than direct learning models on learning outcomes.

Discussion

In the prerequisite test analysis using the students' initial ability test scores and student learning outcomes tests, it was found that the two classes, namely the experimental class and the control class came from normally distributed populations, had homogeneous variances, and the students' initial ability tests were balanced.

After the research process ends, the following is the explanation of research results that there are differences in the effectiveness of the mathematics learning model to stimulate critical thinking compared to the direct learning model. This is based on hypothesis testing with SPSS 20.0 software at a significance of 0.05, it was found that the Sig. = 0,000. So the value of Sig. < α , that is 0,000 < 0.05. So H_0 is rejected, it is meaning that the learning model of mathematics learning to stimulate critical thinking is more effective than the direct learning model of student mathematics learning outcomes.

Besides, in terms of the average test score of the learning outcomes is better than the average value of the initial ability test of students in the experimental class that is 84.4 > 59.42. Based on the percentage of completeness of the two classes shows that the experimental class has a higher percentage than the control class that is 85,7% with an

average class of 84,4 while the control class by 53,57% with an average of 72,9. So it can be concluded that the mathematics learning model to stimulate critical thinking is more effectively applied in learning than the direct learning model of student mathematics learning outcomes.

This is reinforced based on the results of research conducted by Weinstein and Preiss (2017) in their research suggesting the use of scaffolding techniques to develop critical thinking skills and dispositions by using infusion methods to teach critical thinking in the context of certain subject matter. The results stated that the method is effective to help students solve problems, thus learning outcomes will certainly increase. Chukwuyenum (2013) in the results of his research stated that there were significant differences in the scores of mathematics learning tests in the experimental group. Critical thinking skills are an effective way to improve students' understanding of mathematical concepts, therefore it is recommended that in learning mathematics in secondary schools, critical thinking skills must be instilled.

The mathematical learning model to stimulate critical thinking is based on the view that critical thinking is really needed by everyone to address problems in the reality of life. By thinking critically, a person can arrange, adjust, change, or improve his mind, so that he can make decisions to act more precisely. Therefore, critical thinking skills need to be developed in learning, especially mathematics, to prepare students to become strong problem solvers, mature decision-makers, and people who never stop learning. Learning models developed with stages that can help students have critical thinking skills include presenting non-routine and open-ended context problems and applying discussion methods in small groups. This, in line with the opinion of Romberg (1995, p. 51) which said that to build critical thinking in student learning needs to be faced with contradictory and new problems so that he constructs his

mind in search of truth and clear reasons. In addition to providing open problems, during the learning phase also carried out the learning stages following the 2013 Curriculum in the core activities of remembering, understanding, applying, analyzing and evaluating which included activities to understand the material, problem solving through worksheets, group discussions, presentations of group work, and question and answer. Thus, student mathematics learning outcomes taught by the mathematics learning model to stimulate critical thinking are more effective than the direct learning model. That is because the mathematics learning model to stimulate critical thinking will produce critical thinking skills possessed by students. With the ability to think critically it will certainly make it easier for students to solve various problems in learning including solving problems in the problem so that student learning outcomes will be better.

CONCLUSION

Based on the research that has been done, it can be concluded that mathematics learning using mathematical learning models to stimulate critical thinking is more effectively applied in learning compared to the direct learning model of student mathematics learning outcomes.

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