THE EFFECTIVENESS COMPARISON BETWEEN THE METACOGNITIVE APPROACH BASED ON CONTEXTUAL PROBLEMS AND THE SCIENTIFIC APPROACH IN TERMS OF MATHEMATICAL REASONING ABILITY OF THE SENIOR HIGH SCHOOL STUDENTS IN THE LEARNING OF MATHEMATICS

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Abstract

This study aimed to determine: (1) the effectiveness of scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, (2) the effectiveness of the metacognitive approach based on contextual problems in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, and (3) the effectiveness comparison of the metacognitive approach based on contextual problems and the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics.

This research is quasi-experiment with the pretest and posttest design with nonequivalent comparison-control group. The population in this research was all of the students of X MIA of SMA Negeri 1 Purworejo which consisted of 8 classes. The samples were selected using the random cluster sampling technique with class of X MIA 2 as the experimental class which implemented the mathematical learning with the metacognitive approach based on contextual problems and class of X MIA 1 as the control class which implemented the mathematical learning with the scientific approach. The learning at each class was supported by worksheets given by the teacher. The instruments in this reasearch were learning observation sheets and mathematical reasoning ability tests consisting of pretest and posttest. The effectiveness test of the learning used one sample t-test, while the effectiveness comparison test used independent sample t-test assisted by the SPSS version 23 for windows with a significance level of 5%.

The result of this research showed that (1) the scientific approach is effective in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, (2) the metacognitive approach is effective in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, and (3) the metacognitive approach based on contextual problems is more effective than the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics.

Keywords: *metacognitive approach, contextual problems, scientific approach, mathematical reasoning ability*

INTRODUCTION

Mathematical reasoning is a very important ability in solving mathematical problems as well as said by Brodie (2010: 7) that reasoning is the basic skill in mathematics which aims to develop ideas, solve problems, or integrate some of the ideas into a more coherent unity. NCTM (2000: 3-4) states that there are five mathematical learning process standards, one of which is learning to reason and proof (mathematical reasoning and proof).

The importance of reasoning in the learning process is also confirmed by the government through the Curriculum of 2013, which is elaborated in *Permendikbud* No. 64 of 2013 (Kemendikbud, 2013) on the Content Standards for high schools. It mentions that one of the skills that must be mastered is the reasoning in the scope of the concrete and the scope of the abstract associated with the development learned at school independently and is able to use the method according to the rules of science.

In facilitating the ability of mathematical reasoning, an appropriate learning method, learning strategy, or learning approach that can develop students' cognitive ability in organizing their thoughts appropriately in problem solving is necessarily needed. The issue of the metacognitive approach in the learning that is developing in the world of education is believed to facilitate the students' reasoning ability. The term of metacognitive was firstly introduced by Flavell in 1976 derived from the word metacognition. Metacognition refers to a person's knowledge or awareness about the thinking process itself and self-control (self-regulation) for thinking (Flavell, 1976: 231).

Metacognition refers to a way of the high order thinking that involves self-control actively in the process of the cognitive learning. According OLRC News (2004), the regulation of cognition (thinking process) in learning activities includes planning, information management strategies, comprehension monitoring, debugging strategies, and evaluation.

In terms of learning, the metacognitive approach is a learning approach that can help students regulate and control what they learn and tailor to the thinking process ability of each student. In addition, the learning which uses the metacognitive approach needs to be supported with the process of self-regulation. Self regulation is the ability to be an active participant in metacognition, motivation, and behavior in the learning processes (Zimmerman, 1989: 4).

The process of thinking embodied in the activities of mathematical reasoning will be more meaningful when it links with the problems of everyday life which are called the contextual problems. According to the Leader, G. et al. (1995: 78) learning of mathematics that uses understanding of the context of the daily life can improve the learning outcomes and the student activities.

The problems of reasoning using contextual problems are not only found on PISA and TIMSS, but are also found in the National Examination of Senior High Schools. However, the achievement of the National Examination in 2015 is still lacking. Based on the Report of the National Examination of SMA / MA year 2014/2015, the lowest result of the absorption of the National Examination is on the topic or material mastery of geometry with a percentage of 37.58% for the national level (Balitbang, 2015). On the other hand, according to the NCTM (2000: 41), the geometry is a topic that becomes the basis for developing students' reasoning ability.

The low achievement of National Examination in 2015 on geometry material also occured in SMA Negeri 1 Purworejo which the lowest percentage of material mastery is in the topic of geometry. Table 1 below shows the results of the absorption of the National Examination of SMA Negeri 1 Purworejo in 2015 for the indicator of geometry.

Table 1. The result of absorption of National Exam SMA Negeri 1 Purworejo 2015

Tested Capability	School	National
Determining the position, distance and the angle involving points, lines, and planes in space	**41,88**	37,58

SMA Negeri 1 Purworejo is one of the schools which uses the Curriculum 2013 with the scientific approach as the learning approach that is commonly used. The scientific approach is a method that combines the process of observing, asking, trying, associating and communicating in learning (Kemendikbud, 2013).

But in fact, the learning of mathematics in SMA Negeri 1 Purworejo does not always give results in accordance with the objectives set. Based on the observations and interviews with the teachers, it was found that the students tended to memorize formulas and procedural work on the problems as perceived and modeled by the teachers. The problems faced by students is also many of which do not include the contextual problems.

Therefore, this study aims to determine: (1) the effectiveness of the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, (2) the effectiveness of the

metacognitive approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, and (3) the effectiveness comparison between the metacognitive approach based on contextual problems and the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics.

RESEARCH METHODS

This research is the quasi-experimental with pretest-postttest design with nonequivalent comparison control group. In the design of this research, there are two sample groups: the experimental group and the control group which were given a pretest then treatment and then continued with the posttest. The experimental group is a sample group implementing the metacognitive approach based on contextual problems in the learning, while the control group is the sample group implementing the scientific approach in the learning.

This research was done in class X of SMA Negeri 1 Purworejo from February to March 2016 in the 2015/2016 academic year. The population was all of the students of class X MIA of SMA Negeri 1 Purworejo in the 2015/2016 academic year consisting of eight classes. The samples were randomly selected and acquired class X MIA 1 as the control class that implemented the scientific approach and class of X MIA 2 as an experimental class that implements the metacognitive approach based on contextual problems.

In this study, the independent variables is the metacognitive approach based on contextual problems and scientific approach. The dependent variable is the mathematical reasoning ability acquired from the scores of pretest and posttest results in both classes. Meanwhile, the control variables include the teacher, the amount of lesson hours, and the learning material. The teacher is the researcher. The amount of lesson hours in the experimental class and control class are the same that is 14 lesson hours consisting of 2 lesson hours for the pretest, 10 lesson hours for the material learning, and 2 lesson hours for the posttest. Both classes also get the same learning material or topic, which is topic of distance and angle in space as part of the geometry.

The mathematics learning with the metacognitive approach based on contextual problem in this research is the learning that involves the students' ability to control their cognitive aspects based on the contextual problems given and contains of several steps that include: (1) self-regulation, (2) planning, (3) information management strategies, (4) comprehension monitoring, (5) debugging strategies, (6) evaluation, and (7) conclusion.

While the learning with the scientific approach contains of several steps that include: (1) observing, (2) asking, (3) trying, (4) associating, and (5) communicating. Mathematical reasoning ability in this research is the students' mathematical reasoning ability which is indicated by the scores of the pretest and posttest and also contains of indicators of mathematical reasoning as follows:

1. being able to provide an explanation using models, facts, properties, and relations;
2. being able to submit allegations;
3. being able to do mathematical manipulations;
4. being able to check the validity of an argument;
5. being able to use patterns and relations to analyze mathematical situations, drawing an analogy and generalization.

Instrument dan Data Collection Technique

The data collection techniques used in this research are the test technique and non-test technique. The test technique uses the instrument of test of mathematical reasoning ability. Meanwhile, the non-test technique uses the instrument of learning observation sheet.

Moreover, the learning in this research was supported by learning tools that consist of lesson plans and worksheets for the experimental class using the metacognitive approach based on contextual problems and also lesson plans and worksheets for the control class using the scientific approach.

After the instruments were made, then their validity was tested. The validity of the instruments

in this study consisted of the content validity and construct validity. The content validity is determined by the consideration of the expert judgments. Meanwhile, the construct validity is gained through the testing items of each question number of mathematical reasoning ability test using the product moment correlation formula. After the instruments are avowed valid and proper to use, the instruments then were employed.

Data Analysis Technique

The data analysis was done with several steps of the descriptive analysis, assumptions testing, and hypothesis testing. The data that were analyzed descriptively are the mathematical reasoning ability test data either in the pretest and posttest and also data of observation result based on the learning observation sheet.

Furthermore, the next test is the assumption tests which the data distribution normality test and the variance homogeneity test were done with SPSS Statistics version 23 for windows on a significance level of 5%. The normality test used the Kolmogorov-Smirnov test and the homogeneity test used the Levene test.

After the normality test and homogeneity test were tested, it was then continued with the test of average difference in the students' initial ability. This test is done to determine the data that is used to test the hypothesis. If there are no differences in the students' initial ability, then the hypothesis test used the posttest score. However, if there are differences in the students' initial ability, then the hypothesis test used the gain score.

Hypothesis test to determine the effectiveness of the metacognitive approach based on contextual problems and scientific approach used one sample t-test. If both are equally effective or equally ineffective, then they were followed by a hypothesis test to compare the effectiveness of the metacognitive approach based on contextual problems and the scientific approach used independent sample t-test.

RESULTS OF RESEARCH

Overall, the implementation of the mathematics learning both in the experimental class and control class were implemented according to plan, that is 14 hours of lesson hours consist of 2 lesson hours for the pretest, 10 lesson hours for the learning process, and 2 lesson hours for the posttest. Based on the learning observation sheet, the learning perfomance percentage of the experimental class that uses the metacognitive approach based on contextual problems included in the very good category because it has reached 96.18% and the control class that uses the scientific approach is also included in the very good category is 97%.

The description of the mean scores of the pretest and posttest in the experimental class and control class is presented in diagram 1 below.

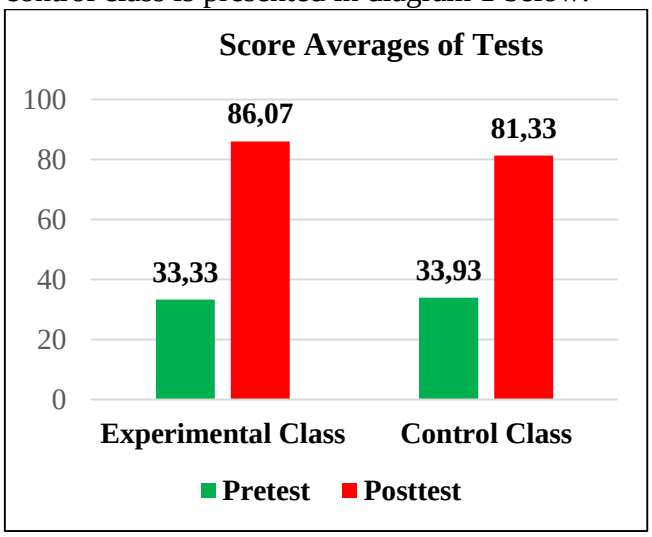

Diagram 1. The Mean Scores of the *Pretest* and *Posttest* in Experimental Class and Control Class

From diagram 1, it can be seen that there is an increase in the mean score obtained during the posttest compared with the mean score during the pretest in both classes. On the data of the pretest, the mean score of the experimental class is lower than the mean score of the control class but it did not show a significant difference. However, on the data of the posttest, the mean score of the experimental class is higher than the mean score of the control class with a significant difference. From the foregoing, it can be concluded that the average of the students' mathematical reasoning ability of the experimental class is higher than the

control class, which means that the experimental class learning is more effective than the control class'.

In addition, the description of the data were also conducted on each indicator of the mathematical reasoning ability as shown in table 2 below.

Table 2. Percentage of Mastery of Mathematical Reasoning Ability on Each Indicator

Indicators of Mathematical Reasoning Ability	Experimental Class		Control Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Indicator 1	30,44	85,26	32,15	80,74
Indicator 2	15,33	84	13,33	72,67
Indicator 3	18,15	77,96	17,78	73,33
Indicator 4	18	90	14,67	94
Indicator 5	43,33	89,21	43,13	83,92

Note:

Indicator 1 : Being able to provide an explanation using models, facts, properties, and relations

Indicator 2 : Being able to submit allegations

Indicator 3 : Being able to do mathematical manipulations

Indicator 4 : Being able to check the validity of an argument

Indicator 5 : Being able to use patterns and relations to analyze mathematical situations, drawing an analogy and generalization

Table 2 above shows that for each indicator of mathematical reasoning ability of the students in the pretest, the percentage obtained experimental class is higher than the control class except on the indicator of providing an explanation using models, facts, properties, and relations. And for each of the indicators of mathematical reasoning ability of the students in the posttest, the percentage that are obtained by the experimental class was also higher than the control class except the indicator of checking the validity of an argument.

Although on some indicators the percentage obtained control class higher than the experimental class, but the average of the mastery of mathematical reasoning ability of the students in the experimental class is higher than the control class as shown in diagram 2 below.

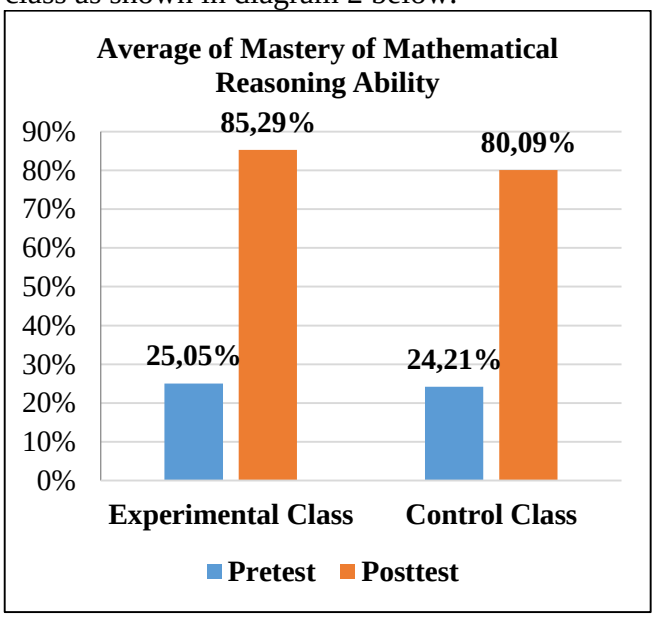

Diagram 2. Average of Mastery of Mathematical Reasoning Ability

In addition to the descriptive analysis, a statistical analysis is also conducted. Before a statistical analysis was conducted to test the hypothesis, the assumption tested that were tested firstly are normality test and homogeneity test.

Based on the the normality test using One-Sample Kolmogorov Smirnov assisted with SPSS version 23 for windows at significance level $\alpha = 0.05$, the result the data of the pretest and posttest scores in the experimental class and the control class were derived from normally distributed population. Other assumption test is homogeneity of variance test. Based on the homogeneity test using Levene test, it was concluded that the variance of the data on both pretest and posttest were the same (homogeneous).

Before the hypothesis test, it is necessary to test the average difference in the students' initial ability to specify what data will be used to the hypothesis test. The normality test and homogeneity test of the pretest data in the experimental class and control class resulted that the data comes from populations with normal distribution and homogeneous, then the test of average difference in the initial ability of the students used independent sample t-test and it concluded that there is no difference on the initial

mathematical reasoning ability among the students of the experimental class and control class. Thus, the hypothesis testing conducted on the posttest score of the students' mathematical reasoning ability.

The first hypothesis testing is to determine the effectiveness of the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics. The mathematics learning with the scientific approach can be told effective in terms of mathematical reasoning ability when the score average of the control class at least reached the KKM of 77. This hypothesis test used One Sample t-test assisted by SPSS version 23 for windows at significance level $\alpha = 0.05$ with the results as shown in table 3 below.

Table 3. Effectiveness Test Result of Scientific Approach

Asumption	*Sig*	*α*	Result
Normal and Homogeneous	0,0065	0,05	Scientific Approach is **effective**

From table 3, it can be concluded that mathematics learning with scientific approach is effective in terms of the mathematical reasoning ability of the students. It is relevant to the research by Habriah Ahmad (2015) which shows that the application of learning models of the discovery learning with the scientific approach can improve the reasoning ability of the students in the learning of mathematics.

The next testing is to determine the effectiveness of the metacognitive approach based on contextual problems in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics. The mathematics learning with the metacognitive approach based on contextual problems can be told effective in terms of the students' mathematical reasoning ability when the score average of the experimental class at least reach the KKM or 77. This second hypothesis test used the One Sample t-test assisted by SPSS version 23 for windows at the significance level $\alpha = 0.05$ with the results as shown in table 4 below.

Table 4. Effectiveness Test Result of Metacognitive Approach Based On Contextual Problems

Asumption	*Sig.*	A	Hasil
Normal and Homogeneous	0,000	0,05	Metacognitive Approach based on contextual problems is **effective**

From table 4, it can be concluded that the mathematics learning with the metacognitive approach based on contextual problems is effective in terms of the students' mathematical reasoning abilities. This is in line with the results of research conducted by Mardiah Aaron (2010) which concluded that the metacognitive strategies can reach the highest level of reasoning or the level of creativity in learning mathematics. This is also supported by the results of Amalia Tri Hutami's research (2015) which concluded that the learning of mathematics with the metacognitive approach is effective in terms of the students' reasoning ability.

Based on the results of the first and second hypothesis testing, the result that the scientific approach and metacognitive approach based on contextual problems are equally effective in terms of the mathematical reasoning ability of the senior high school students in the learning of mathematics, then testing of third hypothesis was done to compare the effectiveness of the metacognitive approach based on contextual problems and the scientific approach in terms of the mathematical reasoning ability of the senior high school students in the learning of mathematics.

The hypothesis testing was done by using independent sample t-test assisted by SPSS version 23 for windows at significance level $\alpha = 0.05$ with the results as shown in Table 5 below.

Table 5. Comparison Effectiveness Test Result

Asumption	*Sig.*	*α*	Hasil
Normal and Homogeneous	0,01	0,05	Metacognitive approach based on contextual problems is **more effective** than scoentific approach

From table 5 it can be concluded that the metacognitive approach based on contextual problems is more effective than the scientific approach in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics.

CONCLUSION AND SUGGESTION

Conclusion

Based on the hypothesis testing we concluded that (1) the scientific approach is effective in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, (2)the metacognitive approach based on contextual problems is effective in terms of mathematical reasoning ability of the senior high school students in the learning of mathematics, and (3) ythr metacognitive approach based on contextual problems is more effective than the scientific approach in terms of mathematical reasoning ability of thr senior high school students in the learning of mathematics.

Suggestion

Mathematics learning using the metacognitive approach based on contextual problems through this research has proved effective to the mathematical reasoning ability of the senior high school students and also more effective than the scientific approach. Teachers are encouraged to use the metacognitive approach based on contextual problems as an alternative approach in the mathematics learning.

In addition, the researchers suggest that other researchers conduct further experiments to test the effectiveness of the metacognitive approach based on contextual problems involving other aspects such as autonomous learning.

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