THE EFFECTIVITY OF MATHEMATICS LEARNING THROUGH POLYA'S HEURISTIC STRATEGY WITH SCIENTIFIC APPROACH IN TERM OF MATHEMATICAL CREATIVE THINKING ABILITY AND THE AUTONOMOUS LEARNING OF SMK PGRI 1 SENTOLO STUDENTS

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Abstract

The aim of this research was to identify the effectiveness of the mathematics teaching and learning through Polya's heuristic strategy with scientific approach in term of the mathematical creative thinking ability and the autonomous learning of SMK PGRI 1 Sentolo students. The design of this research was one group pretest posttest design. The population of this research was class of X in SMK PGRI 1 Sentolo which was three classes and the research sample was the students of Class X AK 1. The factor of this research was the Mathematics teaching and learning by using the Polya's heuristic strategy combined with scientific approach, while the response was the mathematical creative thinking ability and the autonomous learning of the students. Hypothesis testing for the mathematical creative thinking ability data would use the effective criteria if the mean score of post-test was more than the mean score of the pre-test and the students score percentage which achieved more than or equal to 75 was more than 75%. Hypothesis testing for the autonomous learning data would use the effective criteria if the mean score of the final questionnaire was more than the mean score of the first questionnaire and the students score percentage which achieved the good category was more than 75%. Based on the hypothesis testing which used a significance level of 5%, it could be concluded that the Mathematics teaching and learning by using the Polya's heuristic strategy combined with scientific approach was effectively implemented in SMK PGRI 1 Sentolo observed from the mathematical creative thinking ability and the autonomous learning of the students.

Keywords: scientific, Polya's heuristic, creative thinking, autonomous learning.

INTRODUCTION

One of school mathematics learning's focus is to develop the ability to think creatively. Teaching and learning in school should be able to produce a productive, creative, innovative, affective Indonesian through reinforcement of the attitudes, skills, and knowledge that is integrated (Kemdikbud, 2013).

Creative thinking ability is also a capability that is highly desirable to be owned by a vocational high school graduates. Vocational school is a place to prepare a generation that is ready to plunge in the world of work. Meanwhile, one of the capabilities that urgently needed in the world of work is the ability to think creatively. For the students of SMK, in Social groups, administrative offices and Accounting competency, standards of mathematics learning graduates that expected were could thinking critically and could develope creative activities in solving problems and communicate ideas (Depdiknas, 2006). The ability of the creative thinking would be useful to create new innovations in order to help the company or organization as well as to create jobs. Thus, the ability of creative thinking is one of the competencies that are essential to achieve.

The ability to think creativelly could be developed in the learning of mathematics. Learning mathematics can stimulate creative thinking ability of the students because mathematical is essentially can train students

logical thinking. In addition, the math can also train students to analyze a problem. So there is also the term creative thinking mathematically, that creative thinking in mathematics (Tall, 2002).

Creative thinking is identical or close to mathematical talent and creative thinking in mathematical problem solving is the ability to formulate mathematical problems freely, flexible, and smooth, with regard to creative thinking in general (Hartono, 2009). Based on the foregoing the ability of creative thinking in mathematics can also support the ability of creative thinking in general.

In this study, the aspects of mathematical creative thinking and indicators that used are (1) fluency: generate a lot of problem-solving ideas, (2) originality: the delivery of the solution by means of new/unique (different from the other answers), (3) elaboration: steps in order to elaborate in problem solving (Pollete, 2012; Tanner, 1992; Treffinger, 2002).

The ability of creative thinking is closely related to autonomy. People who have the ability to think creatively will more act autonomously. Some of the creative personality trait which is closely related to autonomy are free in thought, like to looking for new experiences, can start their own things (the initiative), free to give opinions, and do not want to receive opinions casually (Munandar, 1982).

Self-reliance or independency is very important in the process of learning activities. Autonomous learning is student behavior in manifesting the will or desires for real by not relying on other people, in this case the student is able to do self-study, can determine how effective learning, able to carry out the learning tasks well and able to perform learning activities independently (Hiemstra, 1994; Harvest, 2000; Scott, 2006). So, independence of learning it is important to have a student.

In this study, some of the indicators used to measure student autonomous learning are: not dependent on other people, have initiative, are able to control themselves, and have an attitude of responsibility (Uno, 2008; Brookfield, 1986).

Polya (1985) introduces the 4 steps in problem solving called heuristics, which consists of understanding the problem, devising a plan, carrying out the plan, and looking back. Heuristic Polya strategy is one of the strategies in problem solving. Treffinger (2002) assumed that the ability of mathematical creative thinking of students relates to the problem-solving abilities of students. So the ability of mathematical creative thinking of students can be trained through learning through Polya heuristic strategies.

At the stage of understanding the problem, the problem must be read to be understood. After students read and understand the problems, students can translate information that is known, including making pictures or diagrams to help students imagine the conditions in issue. This stage is expected to engender creative thinking indicator, fluency.

At the stage of devising a plan, students are required to determine creative strategies to use. On the stage of implementing the plan or carrying out the plan, students can form a systematic problem solving that more fledged, so this step can bring up the indicator of creative thinking, elaboration.

Then, the stage look back or check back can bring up the elaboration indicator and originality at the same time. Because besides students should be reviewing back carefully each step resolution done, students may also explore other different possible answers .

Polya Heuristic strategies are invite students to solve a problem. Students can learn to analyze what is known, determine the problem, determine how the completion of, and seek a settlement in accordance to the plan independently. It is in accordance with the opinion of the Arends (2007) that the benefits of learning that starts from a problems is able to increase self-reliance in learning and social skills of students.

As mentioned by Hosnan (2001:39), the learning steps with a scientific approach that is to observe, to ask, collect data, to associatei, and communicating. Scientific approach can support the achievement of the creative aspects through the stages of the lesson. In addition, the stage of attempting or collect information in scientific approach can also support the self-reliance of students. This is supported by statements in the Permendikbud number 65 by 2013 on the standards of learning process that the Scientific approach can make the students creative thinking, systematic, active, and bring up attitudes and values like responsible, independent, honest, tolerance and cooperation.

From the explanation above, can be seen that Polya heuristic strategy and scientific approach considered has the edge on the side of increasing the ability of mathematical creative thinking and autonomous learning, but by all the knowledge of the researchers are not yet widely used. Observationally, the strategy of heuristics Polya combined with Scientific approach has not been applied in the study of mathematics at SMK PGRI 1 Sentolo. SMK PGRI Sentolo ever apply scientific approach before applying again KTSP. So students of SMK PGRI Sentolo already have experience in learning to follow the steps in the scientific approach and match if given the learning by Polya heuristics strategy with a scientific approach.

Then, based on the results of learning observation in class X AK 1 SMK PGRI 1 Sentolo while learning the material Matrix, seen that learning activities are still centered on the teacher because the learning is still using lectures methods, and the learning process just dominated the records and copy activity. In addition, students tend to be oriented in one answer that was correct and did not explore other ways to solve the problem. At the time of the collection of tasks, there are some students that have not been done the task and does not collect the tasks on time. In addition, at the time the teacher explains learning materials, students are seen not easily understand the material. It is because they have not been studied in advance of learning material at home.

The author also do pre-research by giving tests of the ability of mathematical creative thinking and autonomous learning questionaire to student in class XI AK 1. The average score of the test score is 47.92 from maximum score 100. At the moment there are also observed the student asked to his friend, and cooperate in resolving the test. Meanwhile, the results of the autonomous learning questionaire compiled by Erni Arnitasari (2015) shows 67.9% of students achieve Enough

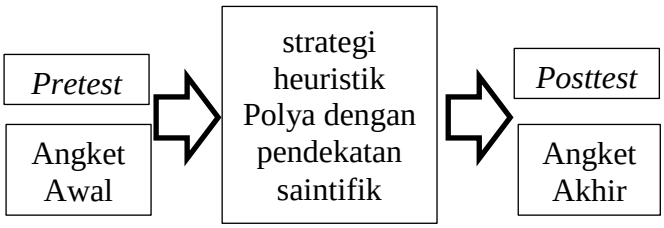
category, 32.1% of students achieve Good category, and the category reaches 0% very good. Based on those results suggest that the ability of the creative thinking and autonomous learning of students in the field are still not optimal.

Based on the above description, researchers intend to do research about the effectiveness of learning mathematics through a Polya heuristic strategy with scientific approach in term of mathematical creative thinking ability and autonomous learning of SMK PGRI 1 Sentolo students.

METODE PENELITIAN

Types of Research

The type of research used in this study was quasi experiment. The design of this research is the One-Group Pretest Posttest Design. Treatment of learning is learning mathematics through a Polya heuristic strategy with scientific approach. Whereas the observed response is the ability of mathematical creative thinking and the autonomous learning of the students.



Research Setting

This study was conducted in SMK PGRI 1 Sentolo at Class X AK 1 of the second semester in the academic year of 2015/2016 on April until May 2016.

Research Subject

The population of this research was grade X SMK PGRI 1 Sentolo in 2015/2016, which is divided into 3 classes. The sample in this research were obtained randomly, i.e. by taking one of the three classes in SMK PGRI 1 Sentolo. From the results of the selection, class X AK 1 selected as a sample of the research.

Data, Instruments, and Data Collection Techniques

The data in this research were obtained from the pretest and posttest of mathematical creative thinking ability score data the, as well as the questionaire score of students autonomous learning that given at the beginning and the end of the learning processes.

The instruments used in this research are tests and questionaire. The test includes pretest and posttest were used to measure the ability of mathematical creative thinking. The questionaire of autonomous learning consists of the first and final questionaire to measure students autonomous learning.

In addition, this research also used the observation method to get information about learning mathematics processes through a strategy of Polya heuristics with scientific approach with.

Data Analysis Techniques

The data used was the result of the pre-test and post-test of mathematical creative thinking ability and the results of the autonomous learning questionnaires in the beginning and the end of the implementation of the study.

The result of the pre-test and post-test of mathematical creative thinking skills showed that there were two hypotheses tests, namely:

1) testing whether the mean score of the post-test was more than the mean score of the pretest,

2) testing whether the percentage of the post-test score which reached minimum score 75 was more than 75%

which were statistically tested by using the following hypotheses:

1) $H_0: \mu_{po} \leq \mu_{pr}$ (the mean score of post-test was not more than the mean score of pretest)
   $H_1: \mu_{po} > \mu_{pr}$ (the mean score of post-test was more than the mean score of pre-test)

p-value= 0,05

The statistical test used was as follows:

$$t = \frac{\bar{p}}{s/\sqrt{n}}$$

$\bar{p}$ = the mean of p_i, where p_i = the score difference (posttest - pretest) on each respondent.

s = p_i standard deviation

n = the number of respondents

The decision criteria is H_0 is rejected if $t_{test} > t_{(\alpha,n-1)}$, where $t_{test} > 1{,}708$.

2) $H_0: p \leq p_0$ (the number of students who reached minimum score 75 less than or equal 75%)
   $H_1: p > p_0$ (the number of students who reached minimum score 75 more than 75%)

p-value= 0,05

The statistical test used was as follows:

$$z = \frac{x - np_0}{\sqrt{np_0q_0}}$$

Where :

x = the number of students who reached minimum score 75

n = number of sample

p_0= 75%, q_0= 1 - p_0= 25%

The decision criteria is H_0 is rejected if $z_{test} > z_{\propto}$, where $z_{test} > 1{,}645$.

In the results of the first and the final questionnaire of the autonomous learning, there were two hypothesis tests:

1) testing whether the mean score of the final questionnaire was more than the mean score of the first questionnaire,

2) testing whether the percentage of the final questionnaire score which reached the minimal category "Good" was more than 75%,

which were statistically tested by using the following hypotheses:

1) $H_0: \mu_{ar} \leq \mu_{aw}$ (the mean score of the final questionnaire was not more than the meaan score of first questionnaire)
   $H_1: \mu_{ar} > \mu_{aw}$ (the mean score of the final questionnaire was more than the meaan score of first questionnaire)

p-value = 0,05.

The statistical test used was as follows:

$$t = \frac{\bar{p}}{s/\sqrt{n}}$$

Where :

$\bar{p}$ = average of p_i, where p_i = the score difference (final - first) on eachrespondent.

s = p_i standard deviation

n = the number of respondents

The decision criteria is H_0 is rejected if $t_{test} > t_{(\alpha,n-1)}$, where $t_{test} > 1{,}708$.

1) $H_0: p \leq p_0$ (the number of the students who reached the minimal category of "Good" was not more than 75%)
   $H_1: p > p_0$ (the number of the students who reached the minimal category of "Good" was more than 75%)

p-value = 0,05.

The statistical test used was as follows:

$$z = \frac{x - np_0}{\sqrt{np_0q_0}}$$

Where :

x =number of students tha reach Good category

n = number of respondents

p_0= 75%

q_0= 1 - p_0= 25%

The decision criteria is H_0 is rejected if $z_{test} > z_{\propto}$, where $z_{test} > 1{,}645$.

To see the classification of the students' autonomy, the calculation of the total score obtained by each student in the final questionnaire was conducted. Eko Putra Widyoko (2009: 238) compares the mean of the total score to the criteria in Table 1.

Table 1. The Classification of The Autonomous Learning Total Score

Formula	Mean	Classification
$X > \overline{X_i} + 1{,}8 \times Sb_i$	$X > 4$	Very Good
$\overline{X_i} + 0{,}6 \times Sb_i < X \leq \overline{X_i} + 1{,}8 \times Sb_i$	$3 < X \leq 4$	Good
$\overline{X_i} - 0{,}6 \times Sb_i < X \leq \overline{X_i} + 0{,}6 \times Sb_i$	$2 < X \leq 3$	Fair
$\overline{X_i} - 1{,}8 \times Sb_i < X \leq \overline{X_i} - 0{,}6 \times Sb_i$	$1 < X \leq 2$	Poor
$X < \overline{X_i} - 1{,}8 \times Sb_i$	$X \leq 1$	Very Poor

Where:

X = empirical score

$\overline{X_i} = \frac{1}{2}$ (the highest ideal score- the lowest ideal score)

$Sb_i = \frac{1}{6}$ (the highest ideal score- the lowest ideal score)

RESEARCH FINDINGS AND DISCUSSION

Table 2 is the statistical data from the students' mathematical creative thinking skills test.

Table 2. Data statistics from the students' mathematical creative thinking skills test.

	Pretest	***Posttest***
Number of students	26	26
mean	38,94	76,54
Mode	0,00	75,00
Standard Deviation	16,24	6,06
Range	58,34	29,17
Highest Score	66,67	91,67
Lowest Score	8,33	62,50
The Possible Minimum Score	0,00	0,00
The Possible Maximum Score	100	100

Table 2 showed that the mean score of the post-test was more than the mean score of the pre-test.

The percentage of students score on the post-test are presented in Table 3.

Table 3. Percentage Of Students Score On *Posttest*

Category	Post-Test Score Percentage	Jumlah Siswa
Not Passed (x< 75)	11,53%	3
Passed ($x \geq 75$)	88,46%	23

With regard to Table 2, it showed that the post-test score percentage which reached 75 was 88.46%. It described that 23 students from 26 students reached the post-test score minimum 75.

Here is data of the students' autonomous learning in Table 4.

Table 4. Data Statistics of the Students' Autonomous Learning

	First Questionnaire	Final Questionnaire
Number of students	26	26
Mean	2,98	3,38
Standar Deviation	0,38	0,33
Highest Score	3,79	3,92
Lowest Score	2,25	2,54
Possible minimum score	1	1
Possible maximum score	5	5

From Table 4, it showed that the mean score of the final questionnaire was more than the mean score of the first questionnaire.

There is Table 5 showing the students' percentage which achieved the minimum classification of "Good" in the final questionnaire of the autonomous learning.

Table 5. The Percentage of the Autonomous Learning Final Questionnaire Classification

Classification	Persentage	Number of students
Good ($3 < x \leq 4$)	92,81%	24
Fair ($2 < x \leq 3$)	7,69	2

From Table 5, it could be seen that the percentage of the students who achieved the minimal classification of "Good" was 92,81%.

Before doing the hypothesis testing, the normality testing was done to determine whether the data come from the populations with normal distribution or not.

Table 6. Normality Test Results

One tested	Normality test			Conclusion
	Sig.	α	Interpretation	
The pre-test score of the mathematical creative thinking	0,885	0,05	H_0 accepted	Normal
The post-test score of the mathematical creative thinking	0,385	0,05	H_0 accepted	Normal
The first questionnaire score of the autonomous learning	0,880	0,05	H_0 accepted	Normal
The finnal questionnaire score of the autonomous learning	0,980	0,05	H_0 accepted	Normal

From Table 6 it indicated that the scores of the pretest, posttest, first questionnaire, and final questionnaire had significance value greater than 0.05. It can be concluded that the scores of the pretest, posttest, first questionnaire, and final questionnaire were derived from the normally distributed populations.

The Effectivity of mathematics learning through Polya heuristic strategy with saintific approach in term of mathematical creative thinking ability

The results of the hypothesis testing showed that:

1) $t_{test} = 11{,}11 > 1{,}708$; then $H_0: \mu_{po} \leq \mu_{pr}$ rejected at the *p*-value 0,05 which indicated that the mean of the post-test score was more than the mean of the pre-test score,
2) $z_{test} = 1{,}651 > 1{,}645$; then $H_0: p \leq P_0$ was rejected at the p-value of 0.05 which indicated that the number of the students reaching the score minimum 75 was more than 75%.

Based on the results of both hypothesis

tests, it could be concluded that mathematics learning through Polya heuristic strategy with saintific approach effective in term of mathematical creative thinking ability.

The results are thought influenced by the scientific learning steps combined with heuristic strategies Polya. The learning proccess always involves a problem to be solved by the students, it is suspected to be a factor in the development of creative thinking ability. Ability of problem solving requires creative thinking ability in exploring various alternative ways or solutions. While the problem-solving activities provide a problematic situation triggers the development of pupils creative thinking (Mahmudi, 2008).

On the strategy of Polya heuristics, students are required to identify the problem. Ruggiero and Vincent (1984) mentions that identify problems is included in this stage of the process towards creativity.

The Effectivity of mathematics learning through Polya heuristic strategy with saintific approach in term of students autonomous learning

The results of the hypothesis testing showed that :

1) $t_{test} = 6{,}521 > 1{,}708$, then $H_0: \mu_{ar} \leq \mu_{aw}$ was rejected at the p-value of 0.05 which indicated that the mean of the final questionnaire score was more than the mean of the first questionnaire score;.
2) $z_{test} = 2{,}038 > 1{,}645$, then $H_0: p \leq p_0$ was rejected at the p-value of 0.05 which indicated that the amount of the students reaching the minimal category of "Good" was more than 75%..

Based on the results of both hypothesis tests, it could be concluded that mathematics learning through Polya heuristic strategy with saintific approach effective in term of students autonomous learning.

Learning mathematics through a strategy of Polya heuristic with scientific approach give effect on student learning independence. One of the characteristics of the scientific approach is centered on the students. So, in scientific approach learning, the students reliance on teachers may be reduced (Hosnan, 2014).

In learning through Polya heuristic strategies with scientific approach, Teachers only serves as a facilitator, while the students have to find concepts independently. This learning approach will be more challenged students again to be able to solve a mathematics problem. As a result students are motivated to be more enterprising again following learning and will eventually grows students autonomous learning. Students may also learn to analyze what is known, determine the problem, determine how the completion of, and seek a settlement in accordance with the plan independently. It is in accordance with the opinion of the Arends (2007:382) that the benefits of learning that starts from an issue of which is able to increase self-reliance in learning and social skills of students.

CONCLUSIONS AND SUGGESTIONS

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Based on the results and discussion on the research about the effectiveness of learning mathematics through a strategy of Polya heuristic with scientific approach in term of mathematical creative thinking ability and autonomous learning of SMK PGRI 1 Sentolo students, it can be concluded that: 1) Learning mathematics through

Polya heuristics strategy with scientific approach can be considered effective in terms of mathematical creative thinking ability of the students of SMK PGRI 1 Sentolo, 2) Learning mathematics through Polya heuristics strategy with scientific approach can be considered effective in terms of autonomous learning of SMK PGRI 1 Sentolo students.

Suggestions

Based on the conclusion above, the authors give suggestions that in order to improve the ability of mathematical creative thinking and student autonomous learning, mathematics teacher at SMK PGRI 1 Sentolo can apply learning mathematics through Polya heuristics strategy with scientific approach.

In addition, base on the findings which have been presented in the discussion, teachers or researchers who want to increase the self-reliance of students are suggested to:

1) divide the group discussions in small groups so that the participation of the students in the group could increase.

2) pay more attention to the division of the discussion group so that the discussions goes well.

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